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PROCEEDINGS OF THE

Twenty-Third Annual Convention

OF THE

American Railway Bridge and Building Association

HELD AT

MONTREAL, QUEBEC

October 21-23, 1913

REPORTS IN THIS ISSUE

Water Supply
Track Scales
Sewers and Drains
Motor Cars for Bridge Gangs
Structures for Supporting Temporary Tracks
Snow Fences
Preservation of Timber
Cattle Guards
Fire Resisting Coatings for Timber
Protection of Concrete in Sea Water

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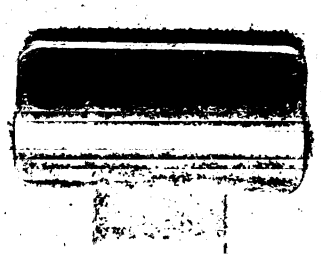
C. A. Lichty, Secretary
226 W. JACKSON BOULEVARD
CHICAGO, ILL.

The Twenty-fourth Annual Convention will be held at Los Angeles October 20-22, 1914



PROCEEDINGS OF THE

Twenty-Third Annual Convention

OF THE

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION

Successor to the

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS

HELD AT

MONTREAL, QUE.

OCTOBER 21-23, 1913

Official Badge

PRICE, ONE DOLLAR

BRETHREN PUBLISHING HOUSE
ELGIN, ILLINOIS
1914

J. N. PENWELL
Lake Erie & Western R. R.

President, 1913-14

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1912-13 A. E. KILLAM, ...Moncton, N. B.

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E. S. Meloy, C. M. & St. P. Ry., Chicago.

3. Railroad Crossing Gates, Towers, etc.

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F. E. Weise, C. M. & St. P. Ry., Chicago, Ill.
F. W. Tanner, B. & O. R. R., Baltimore, Md.
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O. F. Barnes, Erie R. R., Susquehanna, Pa.

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L. D. Hadwen, C. M. & St. P. Ry., Chicago, Ill.
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A. Montzheimer, E. J. & E. Ry., Joliet, Ill.
C. J. Scribner, C. B. & Q. R. R., Chicago, Ill.
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Proceedings of the Twenty-third Annual Convention
of the

American Railway Bridge and Building Association

Held in the Windsor Hotel
Montreal, Que., October 21-23, 1913

MORNING SESSION.

Tuesday, Oct. 21, 1913.

The twenty-third annual convention was called to order at 10 A. M., by President A. E. Killam.

Prayer was offered by Dr. Bruce Taylor.

The President:—Ladies and Gentlemen: We have with us this morning a prominent railroad man, and a past president of the American Railway Engineering Association, Mr. William McNab, principal assistant engineer of the Grand Trunk Railway who will extend to us welcome.

Mr. McNab:—Mr. President and Members of the American Railway Bridge and Building Association: You will allow me to include, also, the members of your families who may be accompanying you, as well as all the other ladies who may be in the room. I wish to confide to you a secret and it is this: I have nothing to do with the committee on weather. I understand that Mr. Gaut and Mr. Johnson were appointed deputy clerks of the weather, and they assured me this morning that every cloud has a silver lining. (Laughter.)

Gentlemen, I am charged with a special duty this morning, but it is a duty that I esteem a very high privilege, and I consider it a special honor to myself that I have to do it. This duty is to bid you a cordial welcome to our city. On behalf of the great railway systems which are centered here, I extend to you most cordial greetings, and I know I am amply justified in saying that this welcome and the degree of warmth with which it is given is shared equally by the people of Montreal generally.

As most of you are aware, this is a very old city. I don't suppose that in continental Europe it would be considered such, but on this side of the Atlantic, any city or institution that can trace its origin back to the early seventeenth century certainly bears the hallmark of ripe old age.

In this city, two of the greatest railway enterprises on this continent, and I think I am not far astray when I say in the world, have their headquarters. For the benefit of the members of this Association I would just like to say that each of these railway corporations has a unique and forceful example of the bridge constructors' art in the immediate vicinity. Each of these structures possesses unique features, unparalleled, probably, in any other similar structure. I might just refer briefly to these. That of the Grand Trunk Railway was originally an iron tubular bridge, a mile and a half long, erected about 53 years ago, which at the time of its erection was looked upon as one of the wonders of the world. The engineers who designed and the contractors who built this structure had to work out much of their own methods; they had to contend with a great many unknown elements, such as climatic and ice conditions, strength of current, etc. Despite their optimism at the time regarding the future of the country they little thought that within 37 years the demands of commercialism and heavier motive power, with increased weight of cars, would necessitate the replacing of that bridge by another; but a few years ago, a double track, modern truss structure replaced the famous old tubular bridge of 53 years ago. The other bridge belongs to the Canadian Pacific Railway, and I do not wish to forestall anything Mr. Motley may tell you on your visit, but that structure is worthy of note. It originally was a single-track structure across the St. Lawrence river, a stream with a mighty current and various other physical problems, but it has been replaced by a double-track structure, which I hope that everybody here will see. I think this Association should feel honored in having among its members the bridge engineer of the Canadian Pacific Railway and the president of the bridge company which fabricated and erected that structure.

It seems to me that in these annual conventions there are at least two distinct features. There is, first, the technical, that is, the scientific or practical, which you labor over and discuss for two or three days, and in the preparation for which the proverbial midnight oil is sometimes considerably lessened in volume. Then

there is the social side, these hours in which personal elements are brought in touch, one with another, and which, besides strengthening friendship's ties, seem to give a particular zest to the successful carrying out of the objects of your Association and to developing the missionary work or labor of love which you are doing for the railway world in general. I suppose that your worthy president will take care of the first part of this throughout these sessions. In regard to the second, I am sure that the friends you meet here will be the means of cementing a bond of common interest between all the members, no matter to what country they owe allegiance, an interest that will be a pleasing oasis in the present instance and also one that will be everlasting.

I am very glad to know that you have this year a Canadian in the presidential chair. It seems to me that this shows good fellowship and my worthy friend to the right seems to have been predestined to occupy the chair on this particular occasion, considering, too, that he is not, if I may use the expression, of the immediate kith and kin of the majority of your members. Although your Association is American in name and Mr. Lichty's office is in Chicago, I know that you members are all big enough and broad enough men to know that the sphere of its usefulness is not limited by the local conditions of Chicago, nor yet is it circumscribed by mere international boundaries. Your fellow members in Canada feel that they are really co-workers with you in all that pertains to the art of bridge and building construction, safety on our railways, and the highest degree of comfort to those who travel, the patrons of the road who employ us. After all, there is only an invisible line between Canada and the United States, such a line as Euclid defines as having length without breadth.

It may have been simply the accident of birth that caused the allegiance of some of us to be south of that line, but our aims in the higher objects of life are all the same. They are analogous; they are not antagonistic, and we can easily prosecute such aims simultaneously, since each of our countries exerts a reflex influence that ought to and does help the other. It must be a great object lesson to the older world and to continental Europe in particular, to know that no matter what nationality the people who compose our heterogeneous population formerly were, they are now Canadian and United States citizens respectively, and we, as nations, endeavor, as far as possible, to develop where neces-

sary, as well as to maintain amongst our newcomers a high and intelligent type of life.

The country to the north of this line is profiting largely by the experiences which you have gone through in the course of your development in trade, in the development of transportation, in your development in everything. Some of that experience, no doubt, has been costly, but it has left no bad effects upon the nation that has gone through that experience. May there never be any war between our two countries—I mean a war bristling with armaments. May there never be any physical barrier between our two nations. May there ever be only that kind of a line which we are indebted to Euclid for defining, and, by reason of such conditions, may there be always a bond of sympathy between our two countries just as strong as that which exists between individuals and sections of each nation respectively. I hope and sincerely trust that both our nations will exert a keen but friendly rivalry in everything tending to promote the arts of education, peace and commercialism in general, scientific research and the highest features of transportation, but more particularly that branch to which you are devoting your lives.

I now wish, on behalf of these railways centered here and on behalf of the people in Montreal generally, to extend to you very cordial greetings, with the wish that this convention of yours may be a banner convention, productive of much good to you personally and to the railways generally, and that the ladies in the room will thoroughly enjoy the social features afforded by our city. (Applause.)

The Chairman:—Ladies and Gentlemen: I now desire to introduce to you one of the past presidents of our Association, who will reply to the able address of Mr. McNab—Mr. B. F. Pickering, of Salem, Mass.

Mr. Pickering:—Mr. President, Mr. McNab, Fellow Members, Ladies and Friends: I hardly know the solution of a problem that has been puzzling me for the last few minutes. That is, why Brother Killam should call on me, who, as you all know, am no orator, to make a reply to such a splendid address of welcome as we have just listened to. I feel entirely inadequate to do justice to the occasion at this time. I wish to say, however, that I have listened with a great deal of interest and very much profit to this kind address.

The thought brought out that the two nations were sepa-

rated by an invisible line appealed to me greatly. As I look here and see the flags of the two greatest nations on earth draped side by side, it occurred to me that there should be no dividing line. We are all one country, we are all one people; there should be no Canada, no United States, no north, no south, no east, no west; it should be one grand America. (Applause.) I think that sentiment will find response in the hearts of all our people. But I wish, also, to say that ten years ago this very month, this Association met, as you know, in the city of Quebec. I was privileged then to have the honored position that Brother Killam holds today, and I want to say just one word from the bottom of my heart, because I have never had a chance to say it where it would do as much good, perhaps, and where it would be as readily understood as this morning. Brother Killam was my right-hand man and the arrangements for the meeting were in his hands. I don't know how he did it, but in some way, he made arrangements for perhaps the best entertainment that we have ever had. When we came to the convention quite a party of us stopped in Montreal the Monday before the convention opened and went on to Quebec Monday night. We met the heads of these great railroads that center here and I never saw a more cordial greeting and better fellowship exhibited anywhere in my life. They simply put the resources of their roads at our disposal, and we have members here in this hall this morning who can testify that they not only did that verbally, but they made good their promises. I assure you that you who attended that convention do not need to have me tell you that it was one of the best planned and arranged meetings that we ever held. Do you wonder that we have a warm place in our hearts for the brother across the border? Do you wonder that "Johnny Bull" (President Killam) is our brother? Do you wonder that we call him an American? (Laughter and applause.) Why, of course. Why shouldn't we? He is Johnny Bull, but just the same he is our brother and it don't make any difference whether he lives in Canada or in the United States, he is exactly as good a fellow and appeals to our hearts just the same. (Applause.) I had a little experience a few years ago, that has been brought to my thought this morning, as our brother has spoken of the two great railroad systems that have their headquarters here, and which I will tell to show how wonderfully these two great railroads have improved in the few years that have elapsed. While returning

from one of our conventions, some of our people will recall that we went to Niagara Falls. My return route was on a branch line of the Grand Trunk—I didn't mean to tell what road it was—(laughter), and I arrived at the station some time before the train was due to leave. While waiting at the station I noticed an official walking around and afterwards I found that it was the superintendent of that division. A little two or three car train was standing on the siding at the lower end of the platform waiting for its leaving time, and a brakeman was sitting on the rear platform, smoking a cigar. Of course, you all know that is contrary to the rules for men on duty. The superintendent walked around there and saw him. The brakeman also saw the superintendent but I don't think he knew who he was. However, he took his cigar out of his mouth and put it behind him. The superintendent turned and passed around some other cars and the brakeman resumed smoking. In a short time the superintendent came around the corner of the car and saw him. He looked at him and said, "Young man, which do you care most for, that cigar or your job?" The young fellow took and gave the cigar another puff. "Well, I don't know, boss," he says, "they are both pretty rotten." (Laughter.)

I mention this to show you that you wouldn't find that on the Grand Trunk today; you wouldn't find it on the Canadian Pacific today. Railroading in all its branches has grown wonderfully, and this Association, Mr. McNab, is keeping pace with the growth of the great railroad systems of this country. Only a few years ago I attended my first convention at Richmond and became a member of this Association. My number, as you know, is 68. That was but very few years ago. Now we have over 600 members, and, as I look over this company this morning and see so many beautiful faces of the wives, daughters and sweethearts of the members of this Association, I feel that it has not only grown in technical interest, but it has grown socially as well. We have come here to Canada to perform our duty as well as to have a grand, good time. Mr. McNab has assured us that the hearts of the Canadian people are with us and I can assure you that Johnny Bull will show you just as good a time here in Montreal as we can possibly enjoy—take it all in. (Applause.)

The President:—Our secretary wishes to make a few remarks.

The Secretary:—Mr. President, Ladies and Gentlemen: This association is now 22 years old. I am pleased to note that nine of our past presidents are in attendance at this meeting. We are pleased to have one of our Canadian members officiate on this occasion when we meet on Canadian soil. We are also gratified to have with us once more "Deacon" Patterson who has been in attendance at every annual convention, and who held the honored position of secretary for 18 years; but most of all, I think, we are pleased to know that we have with us this morning the founder and first president of this association, Mr. O. J. Travis, who has traveled all the way from the state of Washington to be here on this occasion. I would suggest that we accord Mr. Travis a seat of honor beside the president on the platform.

The President:—Mr. Travis, will you please come forward?

O. J. Travis:—Mr. President, Ladies and Gentlemen: It pleases me greatly to be here this morning and to note the growth of the association. My home has been in the extreme western part of the country for a number of years, consequently I have not been able to meet with you as often as I wished. I miss many of the older members, yet I am glad to see the faces of some of the charter members before me here. I feel a keen interest in the affairs of the association, and while I am unable to meet with you from year to year I wish you to know that my heart is with you when you assemble to carry on the work of the organization.

When we met in St. Louis, in the fall of 1891, we did not dare anticipate the results of our feeble efforts which were being put forth at that time. It is not alone the founder, and the noble corps of officers, who have so faithfully guided the affairs of the association in the past, who are responsible for the success to which it has attained, but each and every member who has given his aid and support. I wish to lift my feeble voice in honor of every member who has given of his means and his time with the result that this association has been placed on so high a plane in the affairs of the railroads of this country. I am glad that I am able to be here, and I thank you for honoring me in this manner.

Next in order was the President's address.

PRESIDENT'S ADDRESS.

Members and Friends of the American Railway Bridge & Building Association: Another year has rolled around and I am pleased to meet you in this city of Montreal, the commercial metropolis of Canada. This is our second

meeting in Canada, the first being held in the historic city of Quebec in 1903, 10 years and one day ago.

Since our last annual meeting in Baltimore, Md., a year ago, the grim messenger of death has claimed four of our members: J. M. Wells, A. T. & S. F. Ry., died November 13, 1912; H. D. Cleaveland, B. & L. E. R. R., died November 14, 1912; J. A. Costolo, M. P. Ry., died December 3, 1912, and John Schaffer, N. Y. C. & H. R. R. R., died September 4, 1913. The relatives of these members have our deepest sympathy in their great loss. The hand of time has also taken hold of others of our members so that they cannot meet with us as they thought they would, which causes a further feeling of sadness.

The convention held in the city of Quebec 10 years ago was a profitable one. The places of interest to be seen there were enjoyed by all, the side trips were interesting and the time was well spent. I trust that the time spent here will be no less profitable and enjoyable than that in Quebec.

Our annual conventions are of the highest advantage to the members for there is nothing that will bring out what is in a man like meeting his fellow men face to face. He can then determine how much he knows when he learns how much his neighbor knows.

It is exceedingly gratifying to know that our membership is increasing and that our committees have taken so much pains to prepare such valuable reports as we have before us today. It would be difficult for the chairmen and their committee associates to prepare these reports unaided by the membership in general. However, I must confess that too many members are rather slow in furnishing information in their possession which retards the work of the committees very much.

It is necessary for a railway to have capable officers who understand the interests of the patrons as well as of their railway. They must also have engineers capable of designing their bridges, viaducts, station buildings, etc. These structures must accommodate the steadily increasing weight of engines and rolling stock. The bridge superintendents and inspectors are of as much importance as any other officers in railway service in maintaining a constant watch over the large and small structures to see that they are doing their proper work, and that all nuts, rivets and bolts are in place and tight, in this way safeguarding the traveling public as well as the property of the company.

Thoroughly practical men are necessary for this work, for a structure may be ever so well designed and built and yet the constant passage of heavy trains will cause bolts and rivets to loosen in so many places that only the eye of a practical inspector or bridge superintendent can detect such a failure and report it or have repairs made in time to prevent the further destruction of the property and loss of life.

This association feels that it is of great benefit to the members as well as to the railways they represent and to the public at large. For this reason all bridge and building inspectors and engineers should attend these conventions as far as possible, to learn how to better perform the duties assigned to them. When we return to our homes and resume our various duties on the railway lines on which we are engaged, I trust we will feel so well repaid for our attendance at this convention, as well as at the former conventions, that we will look forward with pleasure to our next annual meeting when further new information will be presented. To live is, and should be, to learn. Therefore, I trust that every member of this association will bear in mind the duty he owes to it and to himself and will give the committees promptly, such information as he may possess. There is nothing so discouraging to a committee as to get a slow response, or none at all.

Apart from the social side, which all will agree is much prized, meeting one another and renewing acquaintance from year to year, our organization is a school for advancing railway bridge and building men in the art and science of their work. It is true that work cannot always be done as quickly and cheaply in one place as in another no matter how clever the man may be, and it is here that the practical man is required to make the best showing out of the situation.

During the past year the proceedings of the 1912 meeting held in Balti-

more have been edited, printed and distributed. These proceedings are a credit to our secretary and to the association and I have received compliments from engineers not belonging to our organization who have spoken in the highest terms of the manner in which the work of this association has been performed. This is most satisfactory and is very pleasing to me, as it must be to all of you.

I cannot close this report without paying a tribute to the ladies who have favored this meeting with their presence. A meeting that the ladies attend, as everyone knows, is a good place to go.

I wish to thank the members of the association for their extreme kindness to me at all times during the 15 years that I have met with them in the different cities of the United States and Canada, not forgetting to mention especially our beloved "deacon" from New Hampshire.

The President:—We will now have a short recess to allow the ladies to retire from the hall, after which we will resume our regular order of business.

(Short recess.)

The President:—The first order of business is the roll call. Instead of calling the roll, cards were distributed for the registration of the members. According to the record the following members were in attendance:

P. Aagaard,	C. F. Flint,	W. F. Meyers,	J. B. Sheldon,
G. Aldrich,	J. B. Gaut,	G. A. Mitchell,	D. A. Shope,
W. E. Alexander,	Ira Gentis,	W. H. Moore,	J. M. Staten,
E. J. Auge,	F. M. Griffith,	C. T. Musgrave,	E. G. Storck,
S. D. Bailey,	E. Guild,	P. J. O'Neill,	W. F. Strouse,
D. A. Ballenger,	J. Henderson,	A. A. Page,	H. C. Swartz,
A. H. Beard,	H. E. Holmes,	S. F. Patterson,	Wm. Sweeney,
S. C. Bowers,	W. T. Hopke,	A. W. Pauba,	S. C. Tanner,
Z. T. Brantner,	H. A. Horning,	W. A. Pettis,	D. B. Taylor,
J. B. Browne,	A. J. James,	B. F. Pickering,	W. H. Tichbourne,
J. M. Caldwell,	Phelps Johnson,	D. E. Plank,	J. E. Toohey,
J. P. Canty,	A. E. Kemp,	H. H. Pollock,	J. E. Travis,
W. M. Cardwell,	A. E. Killam,	C. E. Powell,	O. J. Travis,
F. M. Case,	H. H. Kinzie,	G. W. Rear,	C. F. Warcup,
W. M. Clark,	C. R. Knowles,	R. H. Reid,	P. N. Watson,
W. S. Corbin,	C. A. Lichty,	M. Riney,	F. E. Weise,
J. E. Cole,	E. L. Loftin,	John Robinson,	E. R. Wenner,
C. E. Donaldson,	W. B. MacKenzie,	J. S. Robinson,	W. C. Whitney,
J. Dupree,	A. S. Markley,	E. J. Rykenboer,	J. P. Wood,
H. A. Elwell,	J. H. Markley,	G. T. Sampson,	E. C. Zinsmeister,
C. Ettinger,	A. McNab,	F. E. Schall,	D. C. Zook,
John Ewart,	A. McQueen,	D. W. Sharpe,	

The following applicants for membership, subsequently elected, were also present:

W. Cayley,	A. Larsen,	G. C. McCue,	E. U. Smith,
F. J. Conn,	M. G. Manning,	J. McMahon,	W. J. Tyers,
H. A. Cooper,	A. L. McCloy,	A. W. Reynolds,	John Wilson,
J. H. Johnston,			

Total number of members registered, 100.

The President:—Next in order is the reading of the minutes of the last meeting, but as they have been published and every member has had access to them it will not be necessary to have them read at this time, unless some one has an objection to offer. If there are no objections they will stand approved.

The next order of business is the admission of new members. We will now have the report of the membership committee.

REPORT OF COMMITTEE ON MEMBERSHIP.

To the Members of the American Railway Bridge and Building Association:

Our committee has been busy during the year as will be evidenced by the list of applications presented herewith. Outside of the committee valuable assistance was rendered by G. W. Rear, G. W. Land, W. D. Jameson, J. A. Killian, H. Bender, the secretary and a number of others.

The following list of applicants is submitted for your consideration, and their election to membership is recommended by the committee.

J. B. GAUT, *Chairman.*

LIST OF APPLICANTS FOR MEMBERSHIP.

Andrews, T. O., Gen. For. B. & B., L. E. & W. R. R., Tipton, Ind.
Bohland, J. A., Br. Engr., G. N. Ry., St. Paul, Minn.
Burkhalter, F. L., Dist. Engr., Sou. Pac. Co., Portland, Ore.
Burnett, W. L., For. B. & B., St. L. I. M. & S. Ry., Eudora, Ark.
Byrd, L. J., For. B. & B., St. L. I. M. & S. Ry., Dermott, Ark.
Cayley, W., Supvr., G. T. Ry., Stratford, Ont.
Conn, F. J., Supvr. B. & B., C. N. O. & T. P. Ry., Lexington, Ky.
Connor, R. E., Supvr. B. & B., Southern Ry., Columbia, S. C.
Corey, S. T., Ch. Dftsman, Br. Dept., C. R. I. & P. Ry., Chicago.
Cooper, H. A., Roadmaster, T. I. Ry., Gananoque, Ont.
Cota, G. M., Ch. Clerk, Eng. Dept., C. Vt. Ry., St. Albans, Vt.
DeWitt, H. R., Asst. Engr., Mo. Pac. Ry., Little Rock, Ark.
Draper, I. A., Asst. Supvr. B. & B., P. E. & E. Ry., Portland, Ore.
Gaskin, W., Scale Inspr., Sou. Pac. Co., Los Angeles, Cal.
Gokey, J. C., For. Water Service, G. T. Ry., Richmond, Que.
Harman, H. H., Engr. of Brs., B. & L. E. R. R., Greenville, Pa.
Harvey, E. H., For. W. S., St. L. I. M. & S. Ry., McGehee, Ark.
Henderson, R., For. W. S., B. & O. R. R., Garrett, Ind.
Herrig, C., For. W. S., C. & N. W. Ry., Wall Lake, Iowa.
Johnston, J. H., Supt. B. & B., G. T. Ry., Montreal, Que.
Lamb, C. W., For. B. & B., St. L. I. M. & S. Ry., Pine Bluff, Ark.
Larsen, A., Asst. Engr. G. T. Ry., Montreal, Que.
Lorch, J. A., Asst. Engr., C. & N. W. Ry., Chicago.
Lyman, C. R., For. Brgs., C. Vt. Ry., Waterbury, Vt.
Manning, M. G., Supvr. W. S., C. G. W. R. R., Ft. Dodge, Iowa.
McCloy, A. L., For. B. & B., P. M. R. R., Reese, Mich.
McCoy, W. H., Asst. Engr., Sou. Pac. Co., Dunsmuir, Cal.
McCue, G. C., Gen. Supvr. B. & B., G. T. Ry., Ottawa, Ont.
McIntosh, Wm., Water Engr., B. A. & P. Ry., Buenos Aires, Argentina, S. A.
McMahon, J., Supvr. B. & B., G. T. Ry., Belleville, Ont.
Mellgren, J., For. W. S., C. & N. W. Ry., Eagle Grove, Iowa.
Miller, J. W., Archt., C. & N. W. Ry., Chicago.
Newton, R., For. B. & B., O. S. L. R. R., Pocatello, Idaho.

W. L. Ratliff, Supv. B. & B., I. C. R. R., McComb, Miss.
Reynolds, A. L., Inspr., L. V. R. R., New York City.
Reynolds, A. W., Genl. For., Carp. & Ptrs., P. R. R., New York City.
Reynolds, J. V., For. B. & B., St. L. I. M. & S. Ry., Dermott, Ark.
Roper, D. L., For. B. & B., St. L. I. M. & S. Ry., Monroe, La.
Schoolcraft, C. H., For. Brgs., C. Vt. Ry., Farnham, Que.
Seely, S. A., Supvr., B. & B., N. Y. C. & H. R. R., Watertown, N. Y.
Simmons, I. L., Br. Engr., C. R. I. & P. Ry., Chicago.
Smith, C. W., Asst. Supvr. B. & B., Sou. Pac. Co., Portland, Ore.
Smith, E. U., Asst. Engr., W. & L. E. R. R., Cleveland, O.
Smith, M. A., Gen. For. B. & B., I. C. R. R., New Orleans, La.
Stewart, W. A., For. Brgs., C. Vt. R. R., Stafford, Conn.
Suter, O. M., Supvr. B. & B., I. C. R. R., Chicago.
Stuart, H. B., Struct. Engr., G. T. Ry., Montreal, Que.
Tattershall, E. R., Supvr. B. & B., N. Y. C. & H. R. R., Malone, N. Y.
Tichbourne, W. H., Supvr. B. & B., G. T. Ry., London, Ont.
Tyers, W. J., Supvr., G. T. Ry., Ottawa, Ont.
Ullery, O. E., Asst. Engr., C. & N. W. Ry., Sioux City, Ia.
Wester, C. A., Div. Engr., Sou. Pac. Co., Dunsmuir, Cal.
Wells, L. N., Div. For., B. & M. R. R., Concord, N. H.
White, George W., Asst. Engr., Sou. Ry., Charlotte, N. C.
Wilson, J., Supvr. B. & B., G. T. Ry., Hamilton, Ont.

Total numbers of applications, 55.

The secretary was instructed by a vote of the association to cast one ballot for the election of the applicants named, whereupon they were declared elected and entitled to all rights and privileges of the association.

REPORT OF EXECUTIVE COMMITTEE.

A meeting was held at the Congress hotel, Chicago, March 17, 1913, with A. E. Killam, S. F. Patterson, J. N. Penwell, C. E. Smith, Lee Jutton, L. D. Hadwen, S. C. Tanner, T. J. Fullem and C. A. Lichty present. Mr. Killam reported on the hotel situation at Montreal, stating that the Windsor hotel was best adapted for headquarters for the 1913 convention. The committee was instructed to make arrangements accordingly. On motion of Mr. S. F. Patterson the sum of $200 per annum was allowed the secretary for office rent.

A meeting was held at the Windsor hotel, Montreal, Monday evening, Oct. 20, 1913, at which the following members of the committee were present: A. E. Killam, G. Aldrich, S. F. Patterson, G. W. Rear, S. C. Tanner, and C. A. Lichty. A number of other members of the association were also present. Matters pertaining to the general welfare of the association were freely discussed, but no business of importance was transacted. The committee on arrangements submitted a tentative program for the entertainment of the members while in the city.

C. A. LICHTY,
Secretary.

REPORT OF THE SECRETARY.

Chicago, Oct. 15, 1913.

To the Members of the American Railway Bridge and Building Association:

Twelve hundred copies of the 1912 proceedings were issued, 800 with cloth covers and 400 with paper covers. Three numbers of the Bulletin were issued.

No. of members, 1911-12,	459	
New members, 1912,	54	553
Deceased,	5	
Resigned and dropped,	24	29
Total members, 1913,		524

FINANCIAL.

RECEIPTS.

Balance on hand, last report,	$ 482.84	
Fees and dues,	922.00	
Advertisements,	1,106.60	
Sale of books,	50.70	$2,562.14

EXPENDITURES.

Stationery and office supplies,	$ 27.65	
Postage,	137.05	
Printing and engraving,	1,093.34	
Drafting,	73.25	
Editing,	65.00	
Badges and buttons,	10.60	
Treasurer's bond,	7.50	
Stenographer,	111.45	
Expenses of various committees,	52.63	
Salaries and office rent,	800.00	
Expenses annual meeting, Baltimore,	124.50	
Telegrams, express and exchange,	14.09	
Fire resisting paint tests,	115.25	
Miscellaneous,	2.75	$2,635.06
Deficit,		$ 72.92

Accounts due, $70, which if paid would leave a deficit of but $2.92.

C. A. LICHTY,
Secretary.

The secretary stated that the deficit this year was due to several reasons, viz.: The item of $115 for the testing of fire resisting paints was one such as the association has not had previously. The printing and engraving bills were heavier than in any year heretofore, and the cost of binding the proceedings has of late years been an additional item, while the receipts from advertising have gradually fallen off in recent years.

REPORT OF THE TREASURER.

Boston, Oct. 15, 1913.

To the Members of the American Railway Bridge and Building Association:

The treasurer presents the following report for the year ending Oct. 21, 1913:

Balance on hand Oct. 15, 1912,	$1,360.96
Interest,	51.46
Balance on hand, Oct. 21, 1913,	$1,412.42

Respectfully submitted,

J. P. CANTY, *Treasurer.*

The President:—I will appoint as a committee on auditing the accounts of the secretary and the treasurer, J. S. Robinson, A. S. Markley and C. R. Knowles, and on resolutions, R. H. Reid, J. P. Canty and B. F. Pickering.

Mr. Fred E. Weise was appointed assistant secretary.

The committee on relief offered no report.

The question of the eligibility of applicants for membership was freely discussed, and it was decided that titles should not govern, as different persons who occupy the same relative positions on different railroads have widely different titles, but that the committee on membership should determine who are eligible.

After a recess for the payment of dues and to give an opportunity to become acquainted with the new members, adjournment was taken until 2 P. M.

AFTERNOON SESSION.

Tuesday, Oct. 21, 1913.

The President:—We will at once proceed to the reading and discussion of the reports. The first to be taken up is Subject No. 1, Water Supply, of which Mr. Knowles is committee chairman.

The report was read by the chairman, who stated that this should be considered as a progress report, as it discusses but one phase of the broad subject of water supply, and that the committee desires to take up the various phases in regular order with the aim in view of making the complete report one which would be a credit to the association.

The President:—Gentlemen, the report is open for discussion. (See report and discussion thereof.)

After a thorough discussion mainly with reference to boilers it was decided to accept the report as information and the subject was continued next year.

The Secretary:—The president informed me early in the year that he had invited Mr. MacKenzie, one of our members, who, at that time was chief engineer of the Intercolonial, to prepare a paper for this meeting on the subject of "Concrete in Sea Water." Mr. MacKenzie is here, but informs us that the paper is not ready. However, if he is willing we will listen to an outline of the subject.

Mr. MacKenzie then gave an outline of the subject.

The President:—Next in order is Subject No. 2.

The Secretary:—I will suggest that we carry this report over until Wednesday morning, for several who are interested in the subject can not be here until then.

I will also state that Subjects Nos. 3, 4 and 5 have not been reported upon.

The President:—We will then proceed with Subject No. 6, Sewers and Drains.

None of the members of the committee being present the report was read by the secretary. (See report and discussion.)

Subject No. 7, Motor Cars for Bridge Gangs, was taken up and read by the secretary. This report was not received in time to be published before going to the convention but was read from the manuscript. (See report and discussion.)

At 5:30 P. M. it was decided to hold an evening session, and adjournment was taken until 7:30.

EVENING SESSION.

Tuesday, Oct. 21, 1913.

Meeting called to order at 7:30, with President Killam in the chair.

Subject No. 8, Temporary Structures for Supporting Tracks During Construction of Permanent Work, Sewers, Etc., was presented by the chairman, Mr. W. O. Whitney. (See report and discussion.)

Subject No. 9, Concrete Posts, Poles and Signswas not reported on and it was decided to carry it over for next year.

Subject No. 12, Cattle Guards, was next taken up and in the absence of the committee the secretary read the report. (See report and discussion.)

At 9:30, after several announcements had been made pertaining to features of entertainment, the meeting adjourned to 9 o'clock Wednesday morning.

MORNING SESSION.

Wednesday, Oct. 22, 1913.

The meeting was called to order at 9 o'clock with President Killam in the chair.

Subject No. 10, Snow Fences, was the next to be taken up.

None of the committee being present the report was presented by the secretary. (See report and discussion.)

The President:—Subject No. 2, Track Scales, will be the next to receive consideration.

As none of the members of the committee on this subject were present, the outline of the report was given by the secretary, who also read extracts from it. He stated that the American Railway Association had requested that in view of the fact that their association had a committee on this same subject, which committee had already prepared a set of specifications and other matters, no report on this subject be published by any other association until the American Railway Association was given an opportunity to see it, that all reports be consistent.

After considerable discussion it was decided that the committee on publications and the regular committee on this subject should confer with the secretary of the said association and that after conference and possible revision the report should be printed in the proceedings.

Letters of regret were received from a number of prominent members of the association who were unable to be present, a few of whom are John Foreman, W. M. Noon, C. P. Austin, W. A. McIntyre, J. H. Cummin, Moses Burpee, C. E. Smith, W. F. Steffens, W. A. McGonagle, A. Montzheimer, J. T. Carpenter, C. W. Vandegrift and M. F. Cahill.

The secretary was instructed to send letters of greetings to some of the older members who were unable to be in attendance.

The report of the committee on nominations was read.

REPORT OF COMMITTEE ON NOMINATIONS.

To the Officers and Members of the American Railway Bridge and Building Association:

After careful consideration the committee on nominations submits the following members for officers for the ensuing year:

President, J. N. Penwell; First Vice-President, L. D. Hadwen; Second Vice-President, G. Aldrich; Third Vice-President, G. W. Rear; Fourth Vice-President, C. E. Smith; Secretary, C. A. Lichty; Treasurer, J. P. Canty.

Executive Members:—W. F. Steffens, E. B. Ashby, S. C. Tanner, Lee Jutton, W. F. Strouse, and C. R. Knowles.

The President:—Gentlemen, according to the constitution this report will lie over until Thursday when the election will take place.

On motion of Mr. Pickering the meeting adjourned until 2 P. M.

AFTERNOON SESSION.

Wednesday, Oct. 22, 1913.

Meeting called to order by the President.

Discussion of the Track Scale report was resumed. The secretary announced that Dr. Reichmann, superintendent of weights and measures of the state of New York, and Mr. A. Bousfield, chief engineer of the Fairbanks Co., were in the audience. They were invited to join in the discussion, which they did.

Subject No. 13, Fire-Resisting Coatings for Timber, was next presented. This report was in type-written form, and was read by the secretary. The report demonstrated that the materials used did not prove as effective as was anticipated. (See report and discussion.)

At the close of the discussion of this report it was decided to appoint a committee to make some recommendations as to the value of fire-resisting coatings. (See end of discussion.)

The Preservation of Timber, Subject No. 11, was next to be taken up. The report was read by the chairman, Mr. Rear. (See report and discussion.)

The assistant secretary made some announcements in regard to the side trips, and other features of entertainment.

Mr. Sweeney:—I move, Mr. President, that we proceed to the selection of the next meeting place.

(The motion was seconded and adopted.)

Mr. Rear:—When we were all small boys going to Sunday School we were told of a land that was fairer than day, which some day we might get to if we were good. I would ask Mr. Corbin if he can tell us where that land is?

Mr. Corbin:—California.

Mr. Rear:—It is on the other side of the Rocky Mountains. Very few of you have seen that land. We have in it a city, the "City of the Angels"; you should be sure that you see the City of the Angels once. We place in nomination our city of Los Angeles. The hurrying up of things tonight has sort of blocked us; we were prepared to drown you out and carry you by storm, but as the time is short, we won't do it. We will place in nomination the most beautiful city in the most beautiful state in the world.

Mr. O'Neill:—I don't know whether we want to visit the

"angels" right away or not, but I want to support the nomination and second the motion that we hold our next annual meeting at Los Angeles.

Mr. Corbin:—Mr. O'Neill says he don't know whether he wants to meet the angels or not; that depends on him individually. We have a beautiful city that probably some of you have never seen. Not only is Los Angeles beautiful but the surroundings are beautiful. We have over fifty miles of continuous beach, where one can take a dip any day in the year, if he desires. On New Year's day a great many from the East go in, so that they can tell their people at home about taking a bath on New Year's day. Then we have Pasadena, a beautiful city nestled at the foot of the mountains where a car takes you to the top of Mt. Lowe, from which one can see the ocean. We have a great many other places that I could point out and describe to you, but the hour is late and I will simply say that we wish to give you a hearty welcome in our sunny land; as for Mr. O'Neill, we can find a place for him without angels if he wishes to find one.

Mr. J. H. Markley:—I place in nomination the city of Detroit.

Mr. Clark:—I move that the nominations be closed.

(Motion seconded and adopted.)

A vote was then taken which resulted as follows: Los Angeles 46, Detroit 11.

Meeting adjourned until 8:30 A. M. Thursday.

MORNING SESSION.

Thursday, Oct. 23, 1913.

Meeting called to order at 8:30 A. M. with President Killam in the chair.

REPORT OF OBITUARY COMMITTEE.

To the Members of the American Railway Bridge and Building Association:

Whereas, God, in his infinite wisdom has removed from our midst four of our beloved members, thus severing four more links in the chain of friendship that binds us together, and reminding us of the uncertainty of human life and the certainty of death, therefore, be it

Resolved, That we as an Association sincerely mourn the loss of our beloved brothers, H. D. Cleaveland, J. A. Costolo, J. M. Wells and J. Schaffer.

Resolved, That the sympathy of the Association be tendered to the widows and families of the deceased brothers, and that a copy of these resolutions be printed in full in our Proceedings.

J. N. PENWELL,
Committee.

REPORT OF COMMITTEE ON SUBJECTS.

To the Members of the American Railway Bridge and Building Association:

In selecting subjects for the year 1914 it was necessary to bear two things in mind. A subject must be a live one, full of interest to the members of the association, and it must bring out information and discussions that are of practical value. The members of this association are practical men who are directly concerned in the construction and maintenance of railroad structures, and they are most vitally interested in the methods of doing the work and the materials they are using. The collection of information by the committees, the interchange of ideas brought out in the discussions and the comparing of notes by members outside of the meetings are of direct value to the railroads represented here. The bound volumes of our proceedings are being used as reference books.

The committee had no difficulty in finding interesting and profitable subjects but found it no easy task to select those from which might be obtained the most value by investigation and discussion this year. The list includes some subjects that have been well covered in previous reports but changed conditions and practice warrant us in taking them up again.

The list of subjects, including those carried over from last year, is as follows:

1. Ice houses and the preservation of ice for railway service.
2. Warnings for overhead and side obstructions.
3. Railroad crossing gates, towers, etc.
4. Reinforced concrete bridge work.
5. Station buildings for passenger service only.
6. Mechanical coaling stations.
7. Care of traffic while constructing bridges to eliminate grade crossings.
8. Water supply.
9. Concrete culvert pipe and concrete piles.
10. Heating, lighting and ventilating round houses and shops.
11. Concrete posts, poles and signs.

F. E. WEISE,
W. F. STROUSE,
B. F. PICKERING,
C. E. SMITH,
Committee.

Mr. W. M. Clark suggested that in his opinion it would be a good idea for the association to consider the subject of safety.

REPORT OF THE PUBLICATION COMMITTEE.

To the Members of the American Railway Bridge and Building Association:

The committee on publications met at the call of the secretary and assisted in preparing the proceedings for publication. We again call the attention of our members to the urgent necessity of getting out the reports earlier in order that they may be prepared in due time for the convention. During the past two years the reports have been delayed so that it was impossible to prepare them in time for advance copies to be sent out.

The work of the association is growing in importance and we urge upon the committees concerted action in collecting material for reports from all available sources in order to bring the work up to the highest standard. Our committees may be criticised in depending upon the chairman to do all of the work in connection with getting out the reports.

R. C. SATTLEY,
L. D. HADWEN,
LEE JUTTON,
Committee.

The President:—We will next proceed to the election of officers for the ensuing year.

It was moved and seconded that the rules be suspended and that the chairman of the nominating committee cast the ballot of the society for the list of officers as recommended by the committee.

The motion was carried, and the vote was cast, and the following list of officers was declared elected:

President, J. N. Penwell, Supvr. B. & B., L. E. & W. R. R.
First Vice Pres., L. D. Hadwen, Supt. Const., C. M. & St. P. Ry.
Second Vice Pres., G. Aldrich, Supvr. B. & B., N. Y. N. H. & H. R. R.
Third Vice Pres., G. W. Rear, Genl. Inspr., S. P. Co.
Fourth Vice Pres., C. E. Smith, Chief Engr., Mo. Pac. Ry.
Secretary, C. A. Lichty, Genl. Insp., C. & N. W. Ry.
Treasurer, J. P. Canty, Supvr. B. & B., B. & M. R. R.
Executive Members, W. F. Steffens, C. & O. Ry., E. B. Ashby, L. V. R. R., S. C. Tanner, B. & O. R. R., Lee Jutton, C. & N. W. Ry., W. F. Strouse, B. & O. R. R., C. R. Knowles, I. C. R. R.

The following members were elected to life membership: J. P. Snow, James Parks and Frank Tanner.

A motion was offered by Mr. Reid suggesting that the secretary write a letter of sympathy to Mr. Penwell, who was prevented from being present at the convention by the serious illness of his wife.

Motion carried.

REPORT OF COMMITTEE ON RESOLUTIONS.

Montreal, Oct. 23, 1913.

To the Members of the American Railway Bridge and Building Association:

Resolved, That the thanks of the Association be extended to Mr. Wm. McNab, principal assistant engineer, Grand Trunk Ry., for his address of welcome;

To the Pullman Company and the various railroads, for courtesies shown our members and their families en route to and from the convention;

To the officers of the Grand Trunk and Canadian Pacific railways for side trips and special accommodations to our members and friends;

To Mr. Phelps Johnson and other officers of the St. Lawrence Bridge Co., for the trip through the bridge plant where the great Quebec bridge is being fabricated;

To the representatives of the various railway engineering magazines who reported our proceedings for their several journals;

To the Bridge and Building Supply Men's Association for valuable services in entertaining our members and their friends;

To the officers and committees who gave valuable time and assistance in promoting the general welfare of the Association during the past year.

Respectfully submitted,

R. H. Reid,
J. P. Canty,
B. F. Pickering,
Committee.

President Killam closed the meeting by thanking the Association for the honor which had been conferred upon him, and for the loyal support rendered by all the members during the past year, and urged loyalty and the coöperation of all members to his successor for the coming year.

No further business remaining the association adjourned to meet in Los Angeles, the third Tuesday in October, 1914.

G. K. ANDERSON,
Reporter.

C. A. LICHTY,
Secretary.

MEMOIR.

John Schaffer was born in Buffalo, N. Y., Sept. 16, 1861, and died suddenly at Rochester, N. Y., Sept. 4, 1913. He had finished his usual routine office work on this day when he was stricken with heart failure which caused his death before medical aid arrived.

He began his railroad service with the New York Central & Hudson River R. R. at Buffalo in 1899, as carpenter foreman, was promoted to general foreman in 1904, and served in this capacity until 1908 when he was promoted to supervisor of bridges and buildings at Rochester, N. Y., which position he held at the time of his death. He is survived by his wife and eight children. Funeral services were held in Rochester, N. Y., Sept. 6, 1913, and interment took place in Mt. Hope cemetery, being largely attended by his fellow coworkers and those who worked under his direct supervision.

JOHN SCHAFFER.

Mr. Schaffer joined the association in 1909.

MEMOIR.

H. D. Cleaveland was born in Harbor Creek, Pa., Nov. 25, 1855, and died Nov. 14, 1912, at the home of his nephew, R. W. Elliot, in Cleveland, O. He came from a long line of New England ancestors. His great-grandfather, Rev. John Cleaveland, was pastor of the Congregational church of Essex, Mass., for 55 years. His father, Rev. George W. Cleaveland, was pastor of the Presbyterian church at Harbor Creek, Pa., for 44 years and was for 50 years an active members of the Erie Presbytery.

Mr. Cleaveland secured a practical knowledge of civil engineering as a member of an engineering corps engaged in building the Third Ave. Elevated Railroad in New York City. For a time he followed his profession in North Carolina and was then engaged in engineering work on the construction of a branch of the Ontario & Western, from Cornwall to Middle-

H. D. CLEAVELAND.

town, N. Y. He was also engaged for some years in the engineering department of the Pittsburgh & Lake Erie railroad before he came to Greenville, Pa., as master carpenter of the Bessemer & Lake Erie.

He was married on Dec. 14, 1881, to Ella, the second daughter of Mr. and Mrs. R. W. Genung of Little Britain, N. Y. He leaves a widow and one daughter, Mrs. H. L. Winfree of Lynchville, Va.

Mr. Cleaveland was one of Greenville's most prominent citizens and one of the most active Christian workers in the town. He was a member of the First Presbyterian church of which he was one of the elders. For several years he had been the Sunday School superintendent, resigning when his health began to fail, but was a teacher of one of the classes at the time of his death. The funeral was held from the home of Mr. Cleaveland's sister, and interment was made in Knollwood cemetery, Cleveland.

Mr. Cleaveland joined the association in 1898 at Richmond, Va.

MEMOIR.

JAMES A. COSTOLO.

James A. Costolo, supervisor of bridges and buildings of the Missouri Pacific Railway, was elected a member of this Association at Milwaukee, in 1907, and died at St. Louis, Mo., Dec. 3, 1912, after an operation for hypertrophy.

Mr. Costolo was born on his father's farm, near Fort Loramie, Shelby Co., Ohio, Oct. 12, 1850. While a young man he learned the trade of carpenter and millwright, and was employed by the E. B. Fristoe Contracting Co., of Sidney, Ohio, until he came west in October, 1884, as foreman of erection for the T. J. Prosser Construction Co., St. Louis, Mo., his first work for that firm being the construction of buildings and water stations along the Kansas & Colorado Pacific Railroad, between Kansas City, Mo., and Pueblo, Col., followed by the erection of the present Missouri Pacific System hospital building at Henrietta and California Avenues, St. Louis, Mo. In June, 1890, he was employed by Capt. R. M. Peck (now deceased), one of our Association's first members, then superintendent of bridges and buildings of the Missouri Pacific Railway, as foreman of bridges and buildings, which position he held until placed in charge of the St. Louis Terminals as supervisor. In July, 1906, he was given charge of the company's ferry system, with title of inspector of transfer boats, and continued in that capacity until June, 1912, when the service was turned over to the division superintendent. Not desiring to lose his services the company tendered him other employment, and he accepted the position of supervisor of bridges and buildings on the Illinois division, which he held until his death.

As a final token of respect for a valued workman the railway company placed a special train at the disposal of the family and his remains were taken to their last resting place, where they were interred beside those of his son, at Pacific, Mo.

Beside his widow (nee Jennie Noland), of 6016 Michigan Ave., St. Louis, Mo., to whom he was married January 21, 1877, there survive him a brother, J. W. Costolo, and two sisters, Mrs. Louisa Reiver and Mrs. Margaret Schafer of Lima, Ohio. A son, Frank, born October 5, 1879, died July 8, 1896.

MEMOIR.

JOHN M. WELLS.

John M. Wells was born May 4, 1852, in Washington county, Ohio. Upon the completion of his education he took up the trade of ship carpenter. He moved to Winfield, Kansas, in 1884, where he engaged in building contracting. His railroad service began in the bridge and building department of the Atchison, Topeka and Santa Fe in 1888, with which company he remained in active service until his health began to fail, in 1909, when he retired. He served this company as general foreman of bridges and buildings on the Oklahoma division from 1898 to 1900, on the middle division from 1900 to 1902 and on the Illinois division from 1902 to 1909.

Mr. Wells leaves one son by his first wife, Charles, of Los Angeles, and two sons by his second wife, C. T. Wells, of Los Angeles, and H. E. Wells, of Marceline, Mo. He died Nov. 13, 1912, at Marceline, Mo., and interment was made in Mt. Olivet cemetery at that place.

Mr. Wells joined the Association in 1904 and was elected a life member in 1910.

SUBJECT No 1.

WATER SUPPLY.

REPORT OF COMMITTEE.

The committee presents for your consideration a report on the subject of water supply, including a discussion of various methods of pumping, data on costs of pumping and such other information as it has considered important to the subject. The committee asks that this be considered as a progress report and that it be given further time to consider the various phases of the subject in their regular order.

The problems connected with railway water service are manifold and merit a great deal more attention than they have heretofore received but it is gratifying to know that in recent years the subject of water supply has been given more consideration as its importance has been better realized. The amount of water consumed by our railroads is almost beyond comprehension and can be better understood by presenting comparative figures.

In considering the consumption of water on a railway system of 6,500 miles of road it was found that 16,500,000,000 gallons were used annually. For the fiscal year ending June 30, 1912, there were in operation in the United States 248,888 miles of railroad. Assuming the same average consumption on all railroads throughout the country there are consumed annually something like 632,076,789,000 gallons of water.

The pumpage of the Chicago city water works is 437,232,500 gallons per day. At this rate it would require 1,440 days, or nearly four years for the Chicago waterworks to pump the water used annually by the railroads of the United States.

The twelve reservoirs in the Croton water shed which supply New York City with water and which give a storage capacity of 104,443,000,000 gallons would furnish our railroads with water for about two months. Estimating the water stations to be spaced an average distance of 20 miles it means that it is necessary to maintain 12,444 water stations to pump the water required by more than 60,000 locomotives hauling annually 1,000,000,000 passengers and 2,000,000,000 tons of freight.

In considering the water supply of a railway system with a view of improving present water stations or installing new facilities, it is necessary to consider the development of our railroads within the past few years and in taking care of the present needs to bear in mind the requirements of the future. Water, always an important factor in railway operation, has become of more importance as the tonnage has increased and schedules have been shortened. The old practice of erecting a water tank and establishing a water station at any point where water of any kind was most convenient, will not answer the requirements of the present. With the trains on trunk lines of low gradients, loaded with 2,000 to 4,000 tons and hauled by locomotives with a tender storage capacity of 9,000 gallons, problems of water supply arise which were unknown when the train load of 300 to 500 tons was hauled by a locomotive with a tender storage capacity of from 2,500 to 3,000 gallons.

To provide for the added requirements and to maintain an economical and uninterrupted train movement has necessitated many changes in the location and the methods of pumping, the quality of water furnished, relocating water stations with due regard to curvature and gradients, the installation of improved pumping machinery, and the erection of purification plants for the proper treatment of unsatisfactory waters. The question of railway water supply covers such a wide field that to discuss the subject in an intelligent manner the various phases will be taken up in regular order, begin-

ning with the methods of pumping and the various types of pumping machinery, with an analysis of results obtained in actual practice.

The sources of railway water supply may be divided into the following general classes:

Water from lakes or reservoirs.
Water from creeks or rivers.
Water from wells.
Water from springs.

It of course follows that different methods must be followed in the selection of pumping facilities, depending largely upon the source of supply. The location with regard to fuel supply will also have an important bearing on the type of plant to be installed. If it is desired to operate a pumping plant in connection with existing facilities it will be necessary to conform to the power already used at the plant in question.

For these reasons it is impossible to designate any one type or method of pumping to be followed in general, each particular method having its field of usefulness.

While fuel consumption is the most important factor in pumping efficiency, it often represents only a small part of the cost of operation. In many instances attendance and interest and depreciation charges make up the greater part of the operating expense, and should be given consideration in the selection of a power plant. The figures given on the costs of pumping include only the fuel or power costs as the other items of expense will be influenced largely by local conditions.

Internal Combustion Engines.

The development of the internal combustion engine to operate on the heavier low grade oils is necessary on account of the increased cost of gasoline. Various reasons have been given for the great increase in the cost of gasoline, the real reason being the direct action of the law of supply and demand.

The percentage of gasoline in the petroleum produced each year is growing less and less, for the reason that the fields producing petroleum carrying a large percentage of gasoline are becoming depleted, while the California, Mexico, Texas, Oklahoma and other fields although increasing in production carry a much smaller percentage of gasoline or naphtha. At the same time there has been a great increase in the number of gasoline propelled vehicles, both pleasure and commercial cars (the latter class consuming approximately three times the amount of gasoline required by a car of the first type). The enormous production of gasoline engines for other power purposes is also increasing the consumption of gasoline to such an extent that the higher cost is a natural result. The world's production of crude petroleum by countries in barrels from 1907 to 1911, inclusive, as given by the U. S. Geological Survey, is as follows:

	1907	1908	1909	1910	1911
United States,	166,095,335	178,527,355	183,170,874	209,557,248	220,499,391
Russia,	61,850,734	62,186,447	65,970,350	70,336,574	66,183,691
Mexico,	1,000,000	3,481,410	2,488,742	3,332,807	14,051,643
Dutch E. Indies,	9,982,597	10,283,357	11,041,852	11,030,620	12,172,949
Roumania,	8,118,207	8,252,157	9,327,278	9,723,806	11,101,878
Galatia,	8,455,841	12,612,295	14,932,799	12,673,688	10,485,726
India,	4,344,162	5,047,038	6,676,517	6,137,990	6,451,203
Japan,	2,010,639	2,070,145	1,889,563	1,658,903	1,930,661
Peru,	756,226	1,011,180	1,316,118	1,330,105	1,398,036
Germany,	756,631	1,009,278	1,018,837	1,032,522	995,764
Canada,	788,872	527,987	420,755	315,895	291,095
Italy,	59,875	50,966	42,388	71,905	42,388
Other,	a 30,000	a 30,000	a 30,000	a 30,000	a 200,000
Total,	264,249,119	285,089,615	298,326,073	327,474,304	345,512,185

a—Estimated.

In a bulletin issued by the U. S. Geological Survey in the early part of the year, there appeared a statement giving the estimated production of crude petroleum for the year 1912, in comparison with the year 1911 as follows:

	1911	1912
California,	81,134,391	87,000,000
Oklahoma,	56,069,637	52,000,000
Illinois,	31,317,038	28,000,000
Louisiana,	10,720,420	10,000,000
West Virginia,	9,795,464	11,800,000
Texas,	9,526,474	10,500,000
Ohio,	8,817,112	8,500,000
Pennsylvania,	8,248,158	8,000,000
Indiana,	1,695,289	1,200,000
Kansas,	1,378,819	1,300,000
New York,	952,515	700,000
Kentucky,	472,458	500,000
Colorado,	226,926	200,000
Other States,	194,690	500,000
Total,	220,549,391	220,200,000

It will take much time to calculate the amount of oil sold at the different prices of the year, but it is evident that the total value of the product increased to about $150,000,000 as compared with $134,144,752 in 1911.

The bulletin states further that in all the fields except those of California and the Gulf there was a steady drain on stocks during the year, so that from a total of 81,789,390 barrels—over a half year's output—on January 1st, the stock declined to 69,000,000 barrels at the end of the year. This drain reflects the increased capacity of the refining plants of the United States, the greatly increased exports, and a gradual change in the general condition of the industry by which gasoline has become much more in demand, so that the trade is well satisfied with heavier grades of gasoline or naphtha. For this reason the dividing line between naphtha and kerosene has necessarily been drawn nearer to kerosene and a larger quantity of oil has been distilled into the gasoline portion of the products and a less output of kerosene resulted. On the other hand, the heavy residues which are marketed as fuel oils have come into greater demand, and owing to the continual effort to increase the yield of light products by splitting up these residues the supply of fuel oil has not kept up with the demand. The advent of internal combustion engines such as those of the Diesel type, promises still higher prices for fuel oils. The United States has been slow in the adoption of these new engines but their general adoption abroad has pointed the way to rapid increase in their uses here.

According to figures given by "The Automobile" for January, 1912, the total registrations and production of automobiles for 1911 and 1912 are as follows:

Total registration, 1911,	677,000
Total registration, 1912,	1,010,483
Total production, 1911,	209,957
Total production, 1912,	378,261

The division of types of cars built are as follows:

Types of cars built:

	1911	1912
Gasoline pleasure cars,	194,565	340,746
Gasoline trucks,	8,500	27,909
Gasoline fire wagons,	105	200
Electric pleasure cars,	5,634	8,013
Electric trucks,	553	743
Steam pleasure cars,	600	850
Total,	209,957	378,261

These figures serve to show the causes for the increase in prices of gasoline and emphasize the necessity for an oil engine capable of operating on low grade oils, as the indications are that the price of gasoline will continue to advance.

Internal combustion engines using gasoline as a fuel have been in use for railway water service for a good many years with varying success, depending largely upon the care and attention given the engines.

The advantages claimed for an engine of this type over steam are: lower first cost, less floor space required, can be started more quickly than by firing up a boiler, economy in handling of fuel, proper installation presents a better fire risk and requires less attention. The latter feature is the principal claim to economy in a gasoline engine. Eliminating the services of a regular pumper, and giving the operation of the engine over to some employe in connection with other duties results in a nominal charge for attendance and reduces the cost of operation. This feature of operating a gasoline engine with little or no attention created the impression among many users that it can be run without giving it any attention whatever, except that required to start it. Consequently the operation of the engine in many instances is turned over to some one wholly incapable of properly handling any machinery and possessing no qualification except that of being conveniently located. The resulting effect has been a high cost for repairs and frequent delays and interruption to service, thus destroying the saving that should be expected.

The increasing cost of gasoline has cut down this margin of saving until it has become necessary to look to some other fuel as a substitute. The problem seems to have been partially solved by the use of low grade oils such as kerosene and power distillates. The necessity of using such oils has resulted in great activity on the part of the builders of oil engines and attachments to permit the burning of low grade oils in gasoline engines. No attempt will be made in this report to describe any particular engine or device, but rather to discuss in a general way the question of oil engines for pumping water for locomotives. Proper care and attention are necessary for the successful operation of the oil engine the same as for the gasoline engine and perhaps even in a greater degree if good results are to be expected.

In the course of development of the oil engine widely different types were evolved. In one type known as the "Diesel" the oil is injected into the cylinder by an enormous air pressure, the heat raised by compression being sufficient to burn the oil instantly as it enters the cylinder.

The types which we have to deal with, however, may be divided into two general classes, first a modified form of the above engine which may be known as a two-cycle valveless injection engine in which the compression has been reduced, adding the required temperature in a heated combustion chamber. This engine is governed by throttling the oil supply and ignition is accomplished by the hot tube method, a common form of ignition being by means of a hollow hot ball. This hot ball is heated by a blow torch before starting, but after the engine is running the heat is maintained by the successive explosions. The cycle of operation is as follows:

The air is drawn into the crank case through a port located just below the exhaust port, by the up stroke of the piston; this air is then compressed slightly by the downward stroke of the piston; during the latter part of this stroke the inlet port from the crank case to the cylinder is open and the air is forced into the cylinder against a baffle plate on top of the piston and then to the upper part of the explosion chamber, partially scavenging the cylinder of dead gases. The piston then compresses the confined air into the explosion chamber and ignitor ball, and at the same time the air is mixed with the oil spray which is discharged into the cylinder at high pressure by the oil pump. The temperature of this mixture of air and oil is raised by the heat generated by compression assisted by the heat given off by the walls of the cylinder and head; ignition is now caused by the ignitor ball, the explosion occurs and the piston is forced downward on the power stroke. This operation is repeated at every revolution of the engine. Engines of this type

which inject liquid oil into the cylinder are liable to suffer from carbon trouble and resultant deterioration due to the fact that an excess of oil injected into the cylinder breaks up into volatile compounds, such as the naphthas, heavy tar like oils and free carbon. Improper lubrication also will cause carbon trouble. The high speeds and temperature at which oil engines work necessitates a continuous and skillful use of good oil. A great deal depends upon the proper lubrication of an engine of this type and the prevention of the carbon forming in the cylinder. The destruction of the lubricating oil by combustion cannot be prevented and just what occurs to the oil in an internal combustion engine cannot be entirely explained, but there is no doubt that a great deal of it is burned along with the fuel oil and as long as this is true it is necessary that complete combustion take place in order that a residue of unburnt oil is not left in the cylinder in the form of carbon. The greater the amount of carbon in the oil the greater is the amount of air necessary to form complete combustion.

The lubrication of the steam engine or pump is comparatively simple. In steam engines there is generally a certain amount of water, but the flames of an oil engine dry the internal surfaces and unless the proper amount of oil is applied the cylinder piston and rings soon begin to suffer. In a steam engine or pump the temperature will at the most reach about 500 deg., while in an oil engine it rises to as high as 2,500 deg. Added to this is the fact that the piston speed of an internal combustion engine is from three to four times that of a steam engine or pump. Consequently the oil engine requires a different method of lubrication and a great deal more of it.

Another cause of carbon formation is an overload. When the engine is working up to its maximum power a momentary overload will cause an excess of oil and the resultant accumulation of carbon due to the fact that the oil engine is not flexible enough to adjust itself instantly to the varying loads as does a steam engine or pump.

Another common type of engine burning the low grade oils operates on the well known four cycle principle, consisting of four strokes of the piston or two revolutions of the crank. During the first outward stroke, called the suction stroke, the air is sucked into the cylinder and fuel is either pulled in with the air or in some types is injected by a pump, as with the two cycle engine above described. This is followed by the return or compression stroke during which the piston compresses the charge. Ignition is accomplished by an electric spark in some types and by a hot surface in others; the piston is forced on its second outward or working stroke, and the cycle is completed by the second return stroke of the piston, called the exhaust or scavenging stroke, during which the burnt gases are expelled from the cylinder through the exhaust valve.

Gasoline engines now in service are being converted into oil burning engines by the addition of attachments for pre-heating the oil to the flashing point before the oil enters the cylinder. These attachments consist of generators or mixing chambers wherein the oil is heated by the exhaust of the engine; they are made in various sizes and types both for throttling and for hit and miss governors. With these attachments the engine is generally started on gasoline and is allowed to run on this fuel until the cylinder and generator are heated when the oil is cut in. On other types a retort is provided where the oil is converted into a vapor or gas by heating the retort with a blow torch, either method requiring from five to ten minutes to start an engine running on oil. Very little carbon trouble is experienced with the use of these attachments and the lubrication required is about the same as with a gasoline engine.

A series of tests were made pumping from an eight inch well 190 ft. deep, lifting water against 15 in. of vacuum, with a total head of 61 ft., with an 8 in. x 10 in. single cylinder double acting pump direct connected to a 6 h. p. four cycle horizontal gasoline engine equipped to run on kerosene and distillates as well as gasoline, controlled by a throttling governor.

The fuels used were:

Distillate .....40 degree Baume...Flash .....150Burn ...145
Methyl alcohol 40.5 degree Baume...Burns at same temperature.
Kerosene .....46 degree .....Flash .....124Burn ..170
Gasoline .. ...62 degree ..... Burns at same temperature.
Motor spirits .58 degree ..... Burns at same temperature.

Efficiency Fuel Tests.

	Distillate	Alcohol	Kerosene	Gasoline	Motor Spirits
Lbs. fuel per hour, ...	5.145	6.062	4.943	5.373	4.755
Cost fuel per hour, ...	.0347	.35	.06	.1313	.0975
Pump, rev. per min., ...	43.35	43.32	43.54	43.72	43.79
Pumped, gal. per min., ...175.		177.8	176.8	176.8	178.1
Water horse power, ...	2.69	2.73	2.72	2.72	2.74
Lbs. of fuel per h. p. h., ...	1.91	2.22	1.91	1.97	1.74
Cost of fuel per h. p. h., ..	.0129	.1282	.0220	.0483	.0356
Cost of fuel per gallon, ..	.04625	.40	.08	.15	.13
Pints per hour, ...	6	7	6	7	6
	deg.	deg.	deg.	deg.	deg.
Temperature of cyl. start,..165		90	135	46	46
Temperature of cyl. run, .145		145	145	130	125
Temperature of inlet air, .110		125	120	60	60

As will be seen from the above figures the distillate is the more economical of the fuels used, the cost per water horse power hour being 53 per cent of the cost of pumping with kerosene, and only 27 per cent of the cost of pumping with gasoline. This engine has been successfully operated on distillates from 36 deg. to 42 deg. Baume for a period of three years. The high cost of alcohol eliminates it as a fuel for pumping water and the result of the test is merely submitted as a comparative feature. No doubt better results could have been obtained by reducing the area of the combustion chamber as more compression is required to secure economical results from the use of alcohol in internal combustion engines. The results obtained from the use of kerosene were practically the same as from the distillate, the only difference being in the price of the two fuels. The gasoline test shows such results as might be obtained from the average gasoline engine under the same conditions. The fuel known as motor spirits which has been recently produced as a substitute for gasoline operates under the same conditions as gasoline. The only objectional feature about this oil is a disagreeable odor and it would perhaps be undesirable to use in certain localities.

A 12 h. p. four cycle gasoline engine with a hit and miss governor pulling a 7½ in. x 30 in. working barrel in a deep well was equipped with a generator for burning low grade oils. Comparison tests showed that the engine consumed the same amount of 39 deg. distillate per horse power hour as gasoline the difference in cost of two fuels, however, showing a saving of .0434 per horse power hour in the use of the distillate. The cost of pumping water at this point is comparatively high, due to the fact that the water is pumped with a single acting deep well cylinder which is not as economical as pumping with a surface pump.

The tabulated results obtained follow:

	Gasoline	Distillate
Lbs. of fuel per hour, ...	11.746	12.005
Cost of fuel per hour, ...	$0.219	$0.08
Pump, rev. per min., ...	24	24
Pumped gals. per min., ...	124	124
Water horse power, ...	3.4	3.4
Lbs. fuel per h. p. h., ...	3.458	3.53
Cost fuel per h. p. h., ...	.0643	.0209
Cost fuel per gal., ...	.125	.04625
Pints per hour, ...	14	14
Cost per 1,000 gal. water, ...	.029	.0108

A test was conducted for a period of 30 days on two 20 h. p. vertical, two cycle three port valveless engines, direct connected with a clutch to 9 in. x 10 in. single acting triplex pumps. During the test the engines were run alternately, one pumping days and one pumping nights, each engine running an average of ten hours out of twenty-four. No effort was made to prime the test, the object being merely to show the actual figures under average working conditions.

A total of 10,684,452 gallons of water was pumped against a head of 69 ft. at a cost of $50.20 for oil and lubricants; the fuel used was 39 deg. (Baume) power distillate, flash 126, fire 160; cost per gallon in tank car lots $.045⅛; the cost for fuel alone during the test was $36.14, a consumption of 1,025 lbs. of oil at a cost per h. p. h. of $0.006. The lubricants and kerosene required for blow torches bring the total cost per h. p. h. up to $0.0087. The cost per thousand gallons of water pumped was $0.0049. The engine ran smoothly and maintained practically a constant speed, the variations in speed from readings taken from time to time during the test being from 398 to 403 r. p. m. No repairs of any kind were necessary and the formation of carbon in cylinders was not noticeable. However, the mufflers showed quite a deposit of carbon, there being several pounds of dry carbon in the two mufflers.

The tabulated result of test follows:

Test of 20 h. p. oil engines and 9 in. x 10 in. triplex pumps.

Duration of test,	30 days	
Total number of hours,	609	
39 deg. oil used (.04625),	803 Gal.	$36.14
Cylinder lubricating oil @ 24 cts.,	46 Gal.	11.04
Other lubricating oil @ 18 cts.,	3 Gal.	.54
Kerosene @ 08 cts.,	31 Gal.	2.48
Speed of engine,	400 R. P. M.	
H. P. developed,	6.76	
Actual water pumped,	10,684,452 Gal.	
Total head,	69 ft.	
Total gallons delivered per minute,	292.5	
Actual water h. p.,	5.07	
Total actual h. p. h.,	3,087	
Pounds of oil per h. p. h.,	1.025	
Cost of oil and lubricants per h. p. h.,	.00857	
Cost of fuel oil per h. p. h.,	.006	
Cost of fuel oil per 1,000 gallons,	.0034	
Cost of fuel oil and lubricants per 1,000 gal.,	.0047	

The results from the use of oil in pumping railway water supplies as given above are not the best results to be obtained but represent the cost of fuel used in pumping with oil at the average pumping station. The use of low grade oils has proved to be practical and economical beyond all question. There are conditions where this type of pumping unit would not be satisfactory, particularly where a vatying load would be encountered, but where conditions are favorable as in tank service, and the installation is ample in power excellent results may be obtained, always providing that the proper care is given the installation.

Electricity.

There are few instances where electricity will prove economical as a method of pumping, except where the attendance charge may be eliminated or reduced to the minimum. Where current is purchased from a steam driven electric station the power company will of course expect a profit over the cost of producing the current and overhead expense which is considerable, and it will be difficult to show a saving over a properly installed steam plant.

As many of the new mechanical facilities which are being installed are equipped with electric power plants, it is possible that an electrical pumping

station in connection with the same will furnish water at a low cost, but where current is purchased a very low rate is required to show economy.

It has been difficult to secure figures on the cost of pumping with electricity owing to the limited number of installations in service. Results are given of a test covering a period of 30 days of eight deep well units, each unit consisting of a double acting deep well pump head connected to a 5¾ in. x 15 in. cylinder driven by a 10 h. p. alternating current electric motor delivering water against 160 ft. head. No change was made in the usual method of operating the pumps, the test simply consisting of keeping a record of the performance. The tabulated results follow:

Total number of unit hours run,	3,255
Maximum available running time in unit hours,	5,400
Per cent of maximum available time pumps were run,	60.27
Speed of pumps,	36 R. P. M.
Total gallons pumped,	14,322,000
Pump efficiency, per cent,	60.4
Gallons pumped per unit minute,	73
Water horse power,	2.94
Cost of current per k. w. h.,	.02c
Cost per water horse power hour,	.03.2
Cost per 1,000 gallons,	.02.2

The following figures on pumping with electric power are taken from the proceedings of 1911 giving results as obtained with a 25 h. p. motor driving an 8 in. x 10 in. double acting triplex pump.

Total head in feet,	49
Gallons per minute,	611
Water horse power,	7.6
Cost of current per k. w. h.,	.04
Cost per h. p. h.,	.042

The rate for current in the first table given above is very low and could only be secured where a large amount is consumed, while the rate of four cents would more likely represent the average rate and even at this rate the power company would probably require a contract based upon a minimum amount or a readiness to serve charge.

Steam Pumps.

Steam is most commonly used in pumping water and is economical or otherwise according to the installation and location with regard to fuel supply. In localities where coal is plentiful and a long haul is unnecessary, and where a low grade of coal such as raw screenings can be secured (aside from the question of attendance) water may be pumped by steam almost as economically as by any other power and generally with a great deal more reliability and lower cost of upkeep. This is especially true of a station where a large amount of water is used.

Few railroads have paid sufficient attention to the type of steam plant installed at water stations, having little regard for the steam consumption of the pump and will install any available boiler found unfit for any other service. Consequently the results obtained from many steam plants have not been as economical as they should be, for economical results cannot be secured from the use of obsolete and inefficient equipment.

The boiler is the most important consideration in a steam pumping station as a saving of from 25 to 40 per cent in fuel and repairs may often be effected by the installation of the proper type of boiler. The majority of pumping boilers are of the vertical type with anywhere from 1 to 150 tubes. This type is anything but economical either in fuel consumption or repairs, the only argument in favor of it being that it occupies little space, and is easily moved.

Where a water station is known to be permanent a horizontal return tubular boiler is the proper boiler to install. A boiler of this type will cost

about 100 per cent more to install than one of the vertical type but many of the boiler troubles will be eliminated and the saving effected will justify the additional expenditure.

The following table gives some comparative figures on the cost of pumping with a vertical boiler, return tubular boiler, and a fuel oil pumping unit:

Kind of power, ... Steam	Fuel oil	Steam
Type of pump, ... Duplex	Combined	Duplex
Size of pump,.....14x8½x10"	10 x 12 in.	14 x 8½ x 10 in.
Type of boiler, ... Vertical		Return tubular
Size of boiler, ...60 x 132 in.		54 x 156 in.
Head in feet, ... 150	140	140
Gallons pumped, ... 34,000	74,000	34,000
Gallons per minute, 283	412	283
Fuel used, ...800 lbs.	7½ gals.	360 lbs.
Cost per 1,000 gals. .0235	.0106	.0108
Cost per h. p. h. ... .038	.018	.0183

The above figures were received in reply to inquiries sent out to various roads for data on the cost of pumping, and are typical of results obtained from vertical boilers as compared with horizontal return tubular boilers. It will be seen that the cost of pumping with steam using a return tubular boiler is practically the same as with fuel oil in this particular instance and less than one half the cost of pumping with a vertical boiler.

COMPARISON TEST OF FIRE BOX AND RETURN TUBULAR BOILER.

	Fire Box Boiler	Return Tubular Boiler
Size of boiler, ...	75 h. p.	100 h. p.
Time of test, ...	10 hours	10 hours
Coal used, ...	4,450 lbs.	3,210 lbs.
Feed water used, ...	2,305 gal.	2,167 gal.
Feed water per lb. coal, ...	4.3 lbs.	5.5 lbs.
Gals. water pumped, ...	250,980	263,167
Gals. per minute, ...	418	438
Coal used per 1,000 gal.	17.7 lbs.	12.2 lbs.
Total head in feet, ...	208	208
Cost of coal, ...	$2.22	$1.60
Cost for coal per 1,000 gals., ...	.0088	.0061
Cost for coal per h. p. h., ...	.01	.007

The pumps used in the above test were two 14 in. x 18 in. x 20 in. x 12 in. duplex compound pumps, and the boilers were an old locomotive boiler and a walled in return tubular boiler. The return tubular boiler shows a saving of $0.62 per day of ten hours with coal at $1 per ton. With coal at $2.50 per ton this saving would amount to $1.55 per day or $565.75 per year, which capitalized at 5 per cent represents $11,315.00.

The coal used during the test was raw screenings which accounts for the low evaporation of the boilers. Where a washed nut or other good grade of coal was used the saving would be even greater than is shown above.

This report does not cover fully the different methods of pumping now being used, and no attempt has been made to present a comparison of the different types of pumps, owing to the limited time it has been possible to devote to the work. It is the intention however to continue this discussion in future reports, dealing with each phase of the question of railway water supply, and in so far as possible keep pace with modern methods.

C. R. KNOWLES, *Chairman.*
JOHN EWART,
JAMES DUPREE,
J. B. WHITE,
C. F. WARCUP,
Committee.

DISCUSSION.

(Subject No. 1, Water Supply.)

Mr. Knowles:—The committee asks that this be considered a progress report and that the subject be continued as it is too broad to be covered in a short time.

The President:—Gentlemen, you have heard the report; it is open now for discussion.

Mr. A. S. Markley:—The report states that the return tubular boiler shows a saving of $0.62 per day of ten hours, with coal at $1.00 per ton, and that with coal at $2.50 per ton this saving would amount to $1.55 per day. I don't quite understand those figures. Another thing, an old horizontal boiler is used. Of course, an old boiler is not very good for work of any kind.

Mr. Knowles:—That reference was used because the boiler was certainly old in locomotive service, or it never would have been thrown away; we would never have gotten it in the water department if it had not outlived its usefulness as a locomotive.

Mr. A. S. Markley:—If the boiler was thrown away as unfit for use as a locomotive boiler, why is it good for pumping water? It is our practice to buy a new 50 or 60 h. p. boiler, of the locomotive type. We never were able to see where we could use an old locomotive boiler to advantage as it would cost us more than a new boiler.

Mr. Knowles:—We have a number of old locomotive boilers. As our locomotives become obsolete, we use the old boilers at pumping stations, heating plants, etc.

Mr. Rear:—When a locomotive boiler is used as a stationary boiler, the flues are too small. These boilers are not economical on that account, but a good, big locomotive boiler is first-class for water service. Proper protection from the weather makes a big difference in the amount of fuel used as there will be less radiation if it is properly walled in. There is not the slightest objection to using a locomotive boiler in pumping service, because railroads are using locomotives now with 200 lbs. of steam that used to carry 125 and 140 lbs. What are you going to do with them? One of those old boilers is not worth a cent as scrap, because it costs more to cut it up than one will get for it. If one will use them in the water supply department they are well worth using. I want to ask the chairman of the committee

if he did not find that a two-cycle gasoline engine collected more carbon in the cylinders than a four-cycle?

Mr. Knowles:—Yes, sir.

Mr. Rear:—This is caused mainly by the lubricating oil going in with the fuel oil. On the four-cycle engine, the oil is supplied to the cylinder itself, but in the two-cycle engine the lubricating oil goes into the crank case with the fuel. In the four-cycle engine all the oil that gets into the combustion chamber is that which enters through the cylinder.

Mr. Knowles:—In the two-cycle gasoline engine the oil is mixed with the gasoline, but in this particular engine it has a force feed oiler; that is, an oil pump forces the oil in under pressure. There are three openings around the piston and the oil is forced directly against the piston, but, of course, a great deal of it enters the cylinder back of the piston.

Mr. Rear:—The Committee report says that the lubricating oil should be entirely consumed. Is that as true of four-cycle engines as of two-cycle engines?

Mr. Knowles:—No, I don't think it is, because in the four-cycle engine there is a scavenging stroke and practically all the dead gases are expelled from the cylinder.

Mr. Rear:—We have several electrical outfits. I like them best of all for the reason that they are reliable, but in every case we run them in connection with a big contract. In Sacramento we have a contract with the power companies by which we get all the current we want at 1⅛ cents, even for lighting our uptown office; they will meter for us even for one lamp in our uptown office on a contract for 1⅛ cents for all we use. We swing our drawbridges, run every machine in the shop and light the shops. There are places where the electrical operation of pumps is the most economical and best thing to have, but this depends entirely on whether you can buy the power cheap enough.

Mr. Knowles:—That is one of the few instances where it will prove economical, but in the majority of cases one cannot secure that rate from the public service companies unless he promises them a minimum amount and he cannot afford to do that at the line stations, although he can at the terminals. Returning again to the locomotive and firebox boiler. Reference was made in this committee report to the use of the firebox boiler. This was meant to show that even though we could get that firebox boiler for nothing or very cheaply—we never get it for nothing, because we

always carry a pretty big charge with it—and if we have a very small station where we water only a few engines a day, as stated in the foregoing part of this article, there are many instances where the interest and depreciation charges will make up the principal amount of the expense. In the particular instance mentioned in the report there is no reason why we should operate a locomotive boiler, because it costs us five per cent on $11,000 to use that locomotive boiler. It does not make any difference how cheap we can get the boiler, it is not a paying proposition unless, after they give us the boiler they will then give us five per cent on $11,000; then we can afford to keep it, but we cannot until they do that.

Mr. Rear:—Everyone here knows that the question of our officers giving us a boiler is within our own hands. We can secure a secondhand boiler and they are glad to give it to us; we can get it quickly, but some of them will be backward about coming forward with $1,800 or $1,900 for a new boiler. If there are several divisions on the road and we ask for a new boiler in each case we may not get them. We all know that the pumping is not done in the most economical way, but when the efficiency man gets far enough around, of course we will get everything we ought to have to pump with the least possible cost.

Mr. Knowles:—We don't expect to dispose of all the locomotive boilers right away; but regardless of whether we dispose of them or not, the facts are that they are not economical as compared with a return tubular firebox boiler or a return tubular walled-in boiler. To return to the question of electricity; in terminals we are installing electrical equipment. In these cases where we can get a low rate for electricity, we are justified in using it, but where we have to pay a rate starting at 12 cents and the company will charge us for 30 kilowatt hours per month for each horse power represented in the pump house, we have a pretty big expense to start with, which we have to pay whether we use the power or not. Then the rate will drop and we will pay 6 cents for another 30 kilowatt hours, whether we use it or not. After we have paid that, we can get power at a rate of perhaps 4 or 5 cents. It is difficult to show economy in a case of that kind. I am quoting from an average contract.

Mr. A. S. Markley:—The gentlemen just referred to $1,800 for a pumping boiler. We get 50 and 60 h. p. boilers of the loco-

motive type for $650. There are no figures in this report to show the cost of installation of a return tubular boiler.

Mr. Knowles:—No, we haven't proceeded that far yet.

Mr. A. S. Markley:—Comparing that with a locomotive boiler, we are getting a surplus of power, when we use a locomotive boiler. There is no locomotive boiler that is reduced to 40 or 60 h. p.; consequently, in using that class of boiler, we are using more fuel than you would otherwise in a 60 h. p. boiler. If our officers want to give me an old boiler I tell the mechanical department to let the boilermakers fix it up and they find that it's better to buy a new one. I don't take old scrap. We figure the other way. We want a new boiler and then we have all there is in it. One cannot tell what an old boiler is going to do after it has run for 30 or 40 years on the road.

Mr. Knowles:—I don't recall that figure of $1,800.

Mr. Rear:—I said it would cost $1,800. No one will dispute the fact that a return tubular boiler is the most economical boiler, but if we have a pumping plant that we steam up only one or two hours a day to pump a little water with a big demand some days and not so much on other days and we have a boiler there that gives satisfactory service, we will likely keep on using it forever. We will not dispute the idea that the return tubular boiler is the most economical steam producer.

Mr. Knowles:—The cost of a return tubular boiler properly walled in is about double that of a firebox boiler. One can get a vertical boiler for practically the same cost as the firebox boiler; the 45 h. p. vertical or firebox boiler will cost about $600 erected. A walled-in return tubular boiler will cost about $1,200, or practically 100 per cent increase. The big saving is not in fuel altogether, for where one has either a firebox boiler or a vertical boiler it is in the shop a good share of the time. One has to get a derrick to hoist it out of some hole, because the flue sheet is gone. He can't keep it clean and the result is that he is continually burning the flues off, or dropping the flue sheet and burning it off on top. The same thing occurs with a firebox boiler but not in such marked degree. However they are burning along the the side sheets and in the mud-ring. With the proper kind of a return tubular boiler, there are manholes in the front and back ends above the flues, and the pumper can go in and clean the boiler out. He can scrape the scale off if there is any; hence the big saving is not altogether in the fuel, but in the repairs, par-

ticularly where there is bad water, and consequently one is giving the pumper a chance. I never heard of a pumper being censured for letting his boiler get dirty when he had a boiler of the other type, that I did not defend him, because nobody can keep one of those boilers clean as we operate them at pumping stations. It is difficult even to keep a locomotive boiler clean where one has high pressure, but we will give a pumper one of these little "tea kettles" with a one-inch garden hose and 5 or 10 lbs. pressure and expect him to keep the boiler clean.

Mr. A. S. Markley:—Mr. Knowles has failed to dwell on the cost of installing a return tubular boiler. One has to brick it in, and has to take care of expansion and contraction. Where we have large boilers we have to refire-brick them and give them a general overhauling about every two years, which is not necessary with a locomotive type of boiler. We have about 20 locomotive type boilers and they are giving the very best results. Our pumpers do not blow them up and don't burn them. The boilers are provided with proper manholes to wash them out and they wash them out well so that we have no trouble whatever with them. In our large plants we have two 60 h. p. boilers (some 50 h. p.), and while one is being washed out, the other is operated, or, if crowded, they put on two. We have all brick stacks, consequently, we don't have to renew guys or metal stacks. We have brick walls, concrete floors and everything in good shape.

Mr. Knowles:—Under such condition one can keep them clean, but if he has bad water, he must have trouble with the flues and can't get away from the fuel loss, regardless of the fact that he has ever so good an installation. A locomotive boiler is one of the most wasteful power units in existence and all the energies of the locomotive builders have been directed toward economy in fuel consumption, but it is not practical for pumping water. Mr. Markley speaks of the walled-in boilers. At a great many of our plants we have considerable trouble with the arches and the bridge walls burning out and the fire-brick cracking, but the reason is that the boilers are not big enough and they have to force them all the time. I know of one instance where they are forcing the boilers continually, trying to get steam out of them when they are running constantly at an overload. That will cause trouble and expense from burning out fire-brick lining and arches. My idea in the pumping boiler was to install a boiler of sufficient

size, so we would not have to force it all the time. If it is necessary, put a feed water heater in. We can save one per cent of our fuel in the feed water heater for every 11 degrees we raise the temperature of our feed water.

Mr. A. S. Markley:—Speaking of good water—good water for one boiler is just as good for another and in the majority of our plants where we have the double boilers we have treated water. We treat the water, in some cases pumping it twice before getting it into the storage tank. That, of course, has nothing to do with the boiler, but, as I said before, we have the best results. Of course it is only a question of time until the flues will burn out in any boiler, no matter what the conditions are. Speaking off-hand, I presume that we have boilers in service for the last eight years that we have scarcely touched in any way. After that they will be repaired and need new flues. So far as burning fire-boxes and flue sheets out is concerned, we have no experience in that direction.

Mr. Knowles:—In the walled-in return tubular boiler it is common for flues to last eight or ten years. This brings up another point—the kind of flues one uses. A properly designed return tubular boiler should have good seamless soft steel or charcoal-iron flues. I don't know how one would get such flues, though, unless he analyzed each one, but a flue ought to last eight or ten years in a return tubular boiler, with anything like care and decent water.

Mr. O'Neill:—I don't believe that there is any economy in using old locomotive boilers for pumping, but we simply have to do it. Now, if Mr. Markley can get new boilers for the asking, he is getting along very nicely and I don't blame him for having that kind of boilers. I would too. He says he lets the mechanical department take care of their own old scrap and don't accept it; but on our road the two departments come together under the general manager, and if he says, "You ship P. J. one of your old locomotive boilers," and tells me to put it in and go to pumping with it, I get busy. I have some smaller locomotive type boilers and they work much more economically than the old locomotive boilers. In the first place, I always pity the pumper when I set him to working on an old locomotive boiler because they are built for forced draft. He has to get glasses to help him see through the smoke in the pump house after a while and his eyes get sore. We use the old locomotive boilers and I

expect we will continue to use them unless we can show the general manager where we are going to economize by throwing the old things in the scrap and buying new ones. Even then he won't buy them unless he has the money to spare.

Mr. Alexander:—I am interested in this discussion of boilers, but neither the return tubular boiler nor the locomotive boiler applies to pumping on our road. In this report the committee spoke of the locomotive boiler and nearly ruled it out. It may be true that it is the most costly boiler. On our road, however, we have the vertical tubular boilers which were first installed 20 years ago and they are in service yet. We haven't discarded a boiler that was built 20 years ago, but we have had new tubes put in them. We never had an explosion in a boiler and those boilers seem to give good service for our use. They are from 15 to 18 h. p. with submerged heads. We have never had to put a new head in one of them yet. It may be that our water is much better than that of some of the other people. We have also used the gasoline engine, but gasoline has gone up and it is becoming more costly to operate them. The thing in favor of the gasoline engine is that it is ready to go to work when the man gets there. On our road we have one man attending from two to four pumping places. The section men look after the engines when the pump man is not there, except at his home tank. When the pumper comes he can start up the gasoline engine, do his work between trains, take the next train to the next pumping station, start up the gasoline engine there, go on to the next and do his work there,—much more economically, so far as labor is concerned, than in any other way. I have been quite satisfied with our pumping plants for that reason. They are not large. In some places we are running three of our pumps by electricity, and they are said to be satisfactory. They are doing good work, but I don't know just what the cost is. The locomotive department took charge of the running of the pumps. We make the repairs, but they look after the pumping by electricity, because it is connected with the shops and the men in the shops run the pumps. However, when there is anything wrong we fix it. Under those conditions the vertical boiler and the gasoline pumping outfits have given good satisfaction although they may not be the most economical.

Mr. Knowles:—It is not the intention to discard pumping plants that have given satisfaction, unless we can show a saving,

but the point is, that we have so many of these plants operating at a loss, where the consumption of water is greater than in your case, that if we can show a saving by making the proper installation, it is possible that we can replace this vertical boiler with a return tubular boiler and install the other boiler at a smaller plant where the conditions would not justify a more expensive boiler. These studies regarding the return tubular boiler are meant to cover only cases where a boiler of that size would be desirable. Of course, a return tubular boiler of less than 50 h. p. would not be practical at all, but we have many cases where a boiler of 50 h. p. and over is required. Of course, if we are only going to run the plant a couple hours a day the interest and depreciation charges will overcome the saving effected in fuel several times. It is stated in the closing paragraph of the first part of the report that while the fuel consumption is the most important factor in pumping efficiency, it often represents only a small part of the total cost of operation; in many instances attendance and interest and depreciation charges make up the greater part of the operating expenses. In the case of gasoline engines, if one has several engines which are taken care of by one man, of course he can show a reduction in attendance charges. With a steam plant it would be difficult for him to take care of that number of stations, but it is easily enough done with gasoline.

Mr. A. S. Markley:—Mr. Knowles has not answered my question about fuel arrangements.

Mr. Knowles:—Which question is that?

Mr. A. S. Markley:—In the next to the last paragraph: "The return tubular boiler shows a saving of $0.62 per day of 10 hours, with coal at $1.00 per ton. With coal at $2.50 per ton, this saving would amount to $1.55 per day or $565.75 per year, which, capitalized at 5 per cent, represents $11,315." How is that figured out?

Mr. Knowles:—By referring to this table you will see 4,450 lbs. of coal were used for the firebox boiler. Notice the comparison between this and 3,210 lbs. used in the return tubular boiler; a saving of 1,240 lbs. in 10 hours. 1,000 lbs. would mean 50 cents saved; 250 lbs. would mean 12½ cents—I fudged on you 10 lbs.

Mr. O'Neill:—As regards the economy of steam versus gasoline or electricity, I don't believe that in small plants, where less than 50,000 gallons of water a day is used, steam can be employed as economically as electricity, certainly not as economical-

ly as gasoline. A steam plant requires a man somewhat expert in the use of a boiler and this means a higher rate of pay. Where 50,000 gallons or less is pumped, we can put in a gasoline or an electric pumping plant and get water much more economically than we can with steam, largely on account of the fact that we have to keep a man in constant charge of the steam boiler. I have electric plants running in deep wells with an oil pump on to keep them lubricated, where a man starts them and then takes the train for the next station. When the tank is full a switch is thrown automatically and the plant stops. If the water drops below a certain point in the tank, contact is made again and the pump starts. A man gets around there every morning or sometimes through the day, fills his oiler and stops his pump if it is running to wipe it off and clean it.. He spends perhaps an hour on it; otherwise it takes complete care of itself automatically.

Mr. Knowles:—There's the point exactly, Mr. O'Neill, the attendance charge. You will notice these figures give only the fuel cost, and take no consideration of the attendance charge. Each individual case will have to be figured by itself.

Mr. O'Neill:—I realize that, but the attendance charge will become more prominent right along.

Mr. Knowles:—If one gives the gasoline plants the same attention that he gives the steam plants, he will get uninterrupted service, but we don't put the same kind of a man in charge; consequently, we don't get the same service.

Mr. O'Neill:—I give a station man $10 a month extra to look after a gasoline engine and another fellow $65 a month to look after a steam plant.

Mr. Knowles:—I find that where we have men conveniently located, one man will take care of a gasoline plant and take pride in it, while another man is only looking at the $10 a month that he gets out of it; consequently, we have continual breakdowns and stops for repairs, and before we get through with it, the repairs alone will pay the pumper's salary. Where one can leave an engine shut down a few days, it is another matter, but the stations mainly considered are the heavy stations, where we require a large amount of water. Take the electrical plants; we run them without any attendance, but we don't think it is by any means satisfactory. I received an offer from an electrical concern to equip a pumping station where we used a maximum of 15,000,000 gallons a month, with electrical power and automatic con-

trol. The representative told me what it would pump water for. I told him, "All right, suppose we draw up a contract and make an agreement that you will put the water in the tank for so much a thousand gallons. I will furnish the meter and you guarantee me uninterrupted service." He wouldn't do it. He would give me a bunch of figures, proving what I could do it for, but he wouldn't guarantee uninterrupted service. I never found these automatic floats to work out successfully. In fact, I wrote to one of the largest valve concerns in this country, asking them to quote me a price on an automatic electric valve, and I was advised there was nothing on the market they would recommend. You must have the attention to get the service. I will grant you that on a smaller station one is justified in the use of electricity or gasoline, as the case may be, but in no case, when one considers the fuel alone, is the cost of operating as cheap as with steam. If one can so arrange it that the attendance charge will be eliminated, then he is saving money.

Mr. O'Neill:—I want to say to Mr. Knowles that when we get down to the basic facts, it is the total amount of money that we spend, whether for fuel or for attendance, that shows against our water stations, and if we can save it in attendance, even though the fuel runs a little more, that water station shows up better than another one where we pay more for attendance and less for fuel. It don't seem to me that it is economy to keep a boiler pumping 50,000 or 100,000 gallons a day, if the attendance and other expenses outside of the fuel are so much above the same cost in another plant that they double the expense, regardless of the economy in fuel, where you use steam. It is the entire cost that we have to take into consideration. We cannot select any one item of the cost and base our charges on that.

Mr. Knowles:—That point is admitted, Mr. O'Neill, but you will notice that in making the statement here, the attendance charge is omitted.

Mr. O'Neill:—But you are making a point of the fact that economy of fuel is what counts.

Mr. Knowles:—We refer here to the question of electricity. The statement is made that "there are few instances where electricity will prove economical as a method of pumping, except where the attendance charge may be eliminated or reduced to a minimum. Where current is purchased from a steam-driven electric station, the power company will, of course, expect a profit

over the cost of producing the current and overhead expense, which is considerable, and it will be difficult to show a saving over the properly installed steam plant." It is necessary to take all those points into consideration and if one has some method he is now using that eliminates the attendance charge, it will be very unwise to consider anything that will entail such a charge; and, as you say, even though the power is costing more, you would be justified in using it, providing the additional cost of power was not equal to the additional cost of attendance required at steam plants. One has to check those two figures against each other and the result will show which plant should be used.

Mr. O'Neill:—I have in mind one electrical pump where we are getting a flat rate of 4 cts. on electricity, and the average monthly expense for that power is about $22. We are pumping between 40,000 and 50,000 gallons a day. The attendance and oil, including lubricating oil, bring the cost up to only about $28 a month, and we could not begin to hire a man to shovel the coal for that. In fact we could hardly get the section men to unload the coal for that amount.

Mr. Knowles:—That is true enough in that particular instance, though you are only using about 12 kilowatt hours a day or only about 1⅓ h. p. per hour for 12 hours. That is a light station, and, as you say, necessarily, the attendance charge alone would raise the expense of pumping the water to an unreasonable extent.

Mr. O'Neill:—That is the reason I say that where you are pumping less than 50,000 gallons a day you cannot afford to use steam. This pump works automatically night and day whenever the water gets down.

Mr. J. S. Robinson:—Didn't the committee arrive at some cost of attendance and maintenance including everything that enters into the operating of a water station and secure some average figures for cost per 1,000 gallons? That is what we have to figure on. For instance, on the road I represent, I don't know of any station that don't require from 100,000 gallons to over 4,000,000 gallons a day. We have any number that require 100,000 to 600,000 gallons a day. In Chicago, we take over 4,000,000 gallons every day and we pay 7 cts. per thousand gallons, net. Our own plants run down to 100,000 and some of those 100,000 gallon plants cost us as low as 4½ cents per 1,000 gallons to pump, including everything. Most of those are shallow wells. Of course,

we have to treat the water, in which case it costs 1¾ cents additional for treating it, or a total of 6 or 6¼ cents per 1,000 gallons. We consider that 5 cents per 1,000 gallons is a good price to pay for the water we pump ourselves, including everything, but I would like to ask if the committee did not reach some point that we could use as a minimum or a maximum cost? Of course, we consider Chicago our maximum.

Mr. Knowles:—The figures given here refer to the cost per 1,000 gallons for fuel only. Of course, figures could be given of the cost for attendance, repairs and other items, even figuring in depreciation, but they would not mean anything definite after they were secured. They would simply show the results at one point and would not necessarily mean that one could secure the same results at some other point on the line, because he would probably have to pay more for fuel; the attendance charge might be higher, and other items would enter which would change the total. We have not considered these items, except as information, because the cost per 1,000 gallons does not necessarily mean anything. Some of these costs are figured on a 190 ft. head and others on a 61 ft. head. There is an instance where one head is three times as great as the other; consequently, it has been reduced to horse power hours, in order to arrive at some unit. The figures given are for the consumption of fuel only.

Mr. J. S. Robinson:—Your road is the average road; could you not strike some average cost per 1,000 gallons? That is what the management looks for.

Mr. Knowles:—We could probably get that figure; it would be easy enough in this particular instance, but I fail to see where it would be of any particular value; in fact, it would be rather misleading.

Mr. J. S. Robinson:—We are glad to get almost any kind of boiler, especially a locomotive boiler, but in small plants, of say 100,000 gallons daily consumption, we use a vertical tubular boiler with satisfaction. A locomotive boiler is hard to get out and it is more expensive. A different class of men do the work on the boiler and we are always charged a great deal more for it. What we want is some price we can use for a unit, and that unit is generally 1,000 gallons of water.

Mr. Knowles:—That could be shown, but I don't see the value. One might take the average of the various tests, and even then he would not have much of anything. We will take, for in-

stance, the comparison tests for almost any one of these. To get a proper comparison take what you will have to pay to operate this return tubular boiler and estimate the repair and installation charges. Check this against the other type. Those charges will vary, so that I do not see how we can arrive at any fixed standard. Even on our own lines, the wages paid pumpers vary widely according to the part of the country we are in.

Mr. J. S. Robinson:—That is true, and the cost of fuel also varies. We have to pay more for fuel hauled to Lake Superior than in the Illinois coal fields; still, what we are after is something we can work on as a unit. I thought perhaps you had arrived at some such unit averaging the charges at the ordinary pumping station.

Mr. Knowles:—As far as that is concerned, we found that, everything considered, the average cost for water on many of the roads will run about 5 cents, but the greater part of them do not have any idea of how much water they use or how much it costs. In fact, I had a letter from one gentleman, stating that the water reports sent in had shown from 10,000,000 to 20,000,000 gallons more being used per month than they actually used.

Mr. J. S. Robinson:—What sort of record did he keep?

Mr. Knowles:—That is an open question. For that reason it has been a difficult matter to arrive at any standard. I would say that the average cost for water is about 5 cents per 1,000 gallons, including city water in a great many cases.

Mr. Rear:—There are no two wells or pumping stations that are going to be on an equal footing. We may have a pumping station that does not use very much water, but it is very important that water should be there. Maybe another road may have several stations and it would not make much difference if one of these stations did not always have water because a train can go on to the next. It is about time that we conclude this discussion and I think we have come to conclusions something like this: For small stations, using not more than 25 h. p., an internal combustion engine or an electric plant is to be preferred, especially if the attendance charges can be eliminated or partially eliminated. For larger stations, of 25 h. p. or over and where the supply of water is very important, a steam plant is to be preferred, and of all steam plants the tubular type boiler is most economical. If it is necessary, I will move that we accept this

report and that the conclusions I have just given be the sense of this Association.

Mr. Knowles:—This report is not complete by any means, not even this phase of the subject. It is the desire of the committee to continue the subject from year to year and take up each phase separately in the best possible manner, and for that reason I think it would be best to make no definite recommendations at this time.

Mr. A. S. Markley:—Mr. Robinson made the remark that if you took the locomotive type boiler out of a house, you had to tear the house down or tear out the door, etc. We build our houses large enough and with that in mind. He didn't say that if one takes a return tubular boiler out, he has to tear the brick wall down to take it to the shop. I am not partial; I like to see each get a fair show.

Mr. Knowles:—On that question, I will speak for Mr. Robinson, if he will allow me. The point is that we don't think it will be necessary to tear down that brick wall so often. If one has to move the boiler out and take it to the shop, it will cost considerable. By the time one has done that two or three times he can pay for putting up a new boiler wall.

Mr. A. S. Markley:—You men are attacking the locomotive type boilers, but we have boilers in service for 12 years and have not removed them yet. I don't know how much longer they are going to run.

Mr. Knowles:—You are fortunate.

Mr. A. S. Markley:—We buy them because they are economical.

Mr. Knowles:—We have locomotive type boilers tested and a brass plate put on them, showing what pressure they will carry, etc. We then go ahead and put on whatever pressure the safety valve allows, running them a couple of years. The pumper goes through that weekly or semi-weekly farce of washing the boiler, which consists of marking a cross on a blueprint, saying that he washed that boiler. Maybe he wiped some scales out, but he didn't clean it, and in 18 months we carry that boiler out, probably at night. It costs us anywhere from $75 to $125 to take it out and get it in the shop, and if we have another boiler of the same size, we put that back in its place.

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SUBJECT No. 2.

TRACK SCALES, CONSTRUCTION AND MAINTENANCE.

REPORT OF COMMITTEE.

HISTORICAL.*

Weights and measures have from time immemorial given standards for the traffic of the world. They antedate the use of money of any sort. Metal as money was originally so much weight in the balance; its name was a weight word; the shekel was not at first a coin, but a shekel weight of silver. The talanton of the Greeks was a talent weight; even now the British gold piece retains the old weight name of pound, though more than two-thirds of its original weight is gone. No satisfactory history of weights can be compiled, and the true values of ancient weights are as uncertain as their origin. The Egyptian supposed he got the balance from his god; the Babylonian would say his wise men invented it; the Israelite traced it back to Cain.

The earliest illustrations of the process of weighing are found on the temple walls of Egypt, dating back to the Rameses and the Thothmes kings. Here the balance appears, having gold rings on one side, counterpoised by a weight in the shape of an ox head on the other. The ox unit of value, i. e., the average worth of an ox or cow, was everywhere current in primitive times. The Homeric ox unit has been calculated as on an average equivalent to 135 grains of gold. The most accurately defined weight is probably the Babylonian mina, discovered by Petrice in Egypt, and now deposited in the British Museum. This is of serpentine stone, conical in shape, of a weight of 15097.6 grains, with this cruciform identification: "One Manch, standard weight, the property of Meridach,—sar I lami, and duplicate of the weight which Nebuchadnezzar, King of Babylon, made in exact accordance with the deified weight of Dungi, a former king." According to Layard's tables, the derived weight of one mina seems to have approximated that of a pound avoirdupois.

Early Babylonian weights were of stone or bronze, and in a rude resemblance to ducks and lions, by which terms they are now designated. Those found by Layard in the king's palace are assumed to have been deposited as standards. One of these is inscribed, "The palace of Irta Merodach, King of Babylon, 30 Manchs." This was about B. C. 1030.

The Chaldeans were experts in science; their metric system of time reckoned by 60's has never been improved upon. Many suppose their weights and measures system to have been upon the same basis. They ingeniously determined the length of an hour equinoctial time by means of the dropping of water, 60 drops making a minute, 60 minutes an hour. In like manner, the amount by weight that in a given time dropped from one vessel into another would give units for weight and measure, and these would read 6 shekels make a mina, 60 mina make a talent. The weight of a cubic foot of water was originally introduced by the Chaldeans.

The process of weighing first appears on the page of written history in the record of Abraham's transactions with the sons of Heth. The 400 shekels which he paid them for a burial place were weighed out

*Contributed by A. Bousfield.

in a balance. It is reasonable to infer that both the balance and the shekel weight were Egyptian or Babylonian.

By order of Moses, a set of weights, also of measures, was deposited in the tabernacle under cognizance of the priests. These were the authenticated standard to which all must conform. The unit of weight was the shekel, equivalent originally to one ounce avoirdupois, but in later times much less. The relation between standard weights and liquid and dry measures prevailing in England from earliest times is summed up in Act 51 of King Henry III. A. D. 1266, "By consent of the whole realm of England, an English penny called a sterling, round and without any clipping shall weigh 32 wheat corns in the midst of the ear; and 20 pence do make an ounce and 12 ounces one pound, and 8 pound do make a gallon of wine and 8 gallon of wine do make a London bushel, which is the eighth part of a quarter." This standard was afterward abandoned. Specimens of standard weights, the oldest now existing in England, are a set of ball shaped avoirdupois weights of 56, 28 and 14 lbs., a set of 7, 4, 2, and 1 lbs., a set of flat circular avoirdupois weights of 8 lbs. to 1-16 oz., a set of cup shaped troy weights nested together of 256 oz. down to ⅛ oz. These were constructed in 1586 by order of Queen Elizabeth.

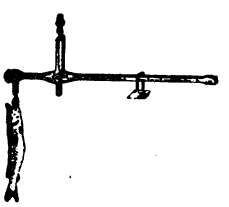
The only standards known in the American colonies were those of Great Britain. Under the articles of confederation, also under the constitution, authority to fix the standard of weights and measures was vested in Congress.

In 1828 Congress legalized the brass troy pound weights brought from England the year before by Minister Gallatin to be the standard troy pound of the mint of the United States, conformality to which the coinage thereof shall be regulated.

For revenue and general government use, a copy of the British avoirdupois pound, made and presented to the United States, is standard.

The device always and everywhere used for weighing has been the balance, originally a simple wooden beam of equal arms, or as in later times, elaborated and multiplied by compound levers till thousands of pounds could be balanced by a small counterpoise.

The even balance is the simplest form of weighing apparatus and the earliest in point of time. The balance is a lever of the first class having even or equal arms. From each end is suspended a pan, one for the load to be weighed, and the other for the weights. An index needle



The Steelyard was adapted to the weighing of small packages only.

Fig. 1.

or indicator is sometimes attached to the lever, and points to a graduated dial attached to the pillar, the indicator being used to show when the scale is in balance. The even balance is not in common use in this country except for small loads or exceedingly fine weighing, but is largely used in England.

The steelyard introduced by the Romans is the earliest form of a well constructed multiplying balance. A specimen of this taken from the ruins of Pompeii has graduated divisions on the long arm of the beam x to xxxx lbs., with a v on the half pound, also some smaller subdivisions.

Though prior to 1830 various devices for the weighing of commodities upon scales having a platform, supported by levers underneath had

been invented, some of these were patented and had gone into limited use, but the first platform scales which were commercially successful were those made by E. and T. Fairbanks at St. Johnsbury, Vt. This scale was patented June 13, 1831. In the fall of 1830 the farmers of Vermont in the vicinity of St. Johnsbury were bringing in loads of rough hemp to a dressing factory recently established in that town, and these loads must be weighed. Many of the towns had scales like those in use in England, great steelyards suspended high up, from the short arm of which hung platforms that could be swung clear of the ground or chains that could be hooked around the axles of the carts to be weighed, and a similar scale was constructed for the hemp factory. This was inconvenient and the manager, Mr. Thaddeus Fairbanks, conceived the idea wholly novel to him of a platform level with the ground, and supported by levers underneath.

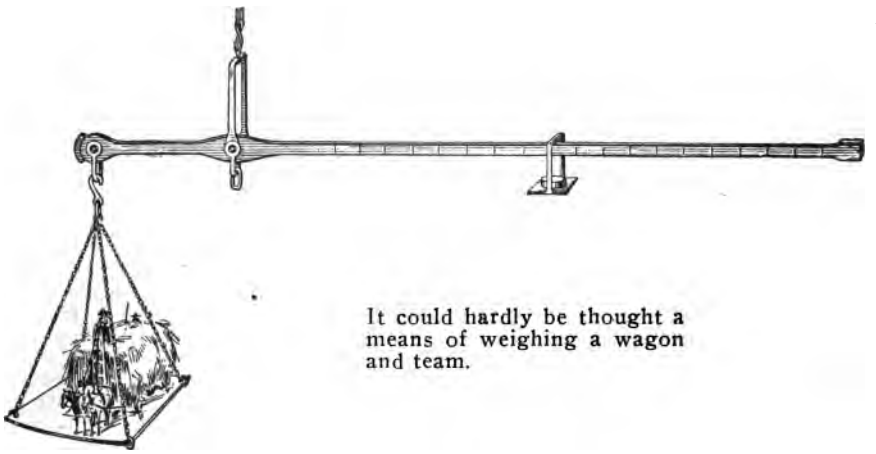


Fig. 2.

He first constructed a scale consisting of such a platform resting in the middle upon knife edges in line, fixed upon the upper side and near the wide end of a triangular or A-shaped lever, of which the wide end was carried by proper bearings under the platform, and the apex hung by a steelyard rod from a beam pivoted and graduated like the old Roman steelyard. To keep the platform balanced upon the supporting knife edges, he framed into it a stiff post, from the top of which lever check chains were carried to a post set in the ground.

Mr. Fairbanks' next thought was to combine two such levers under the platform and thus support its four corners. This was the first type of Fairbanks' platform scale. Mr. Fairbanks immediately perceived its advantages, and made patterns and constructed a scale.

At St. Johnsbury the wagon scales were first built with two wooden levers carrying steel knife edges in proper bearings. Finding that standard pound weights varied in the several states, the Fairbanks brothers took great pains to find the correct weight and obtained test weights compared with the New York standard, which was found to be correct when Congress distributed U. S. standard weights in 1836, so that the

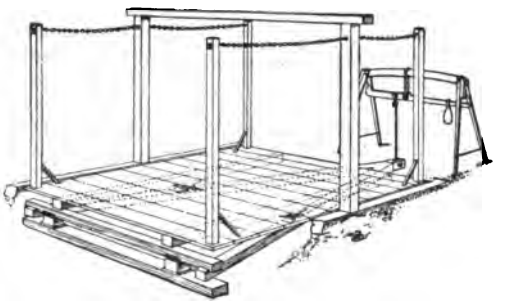


Fig. 3.—The First Wagon Scale Ever Made.

introduction of the Fairbanks scale did much toward unifying the standard of the country.

The most remarkable result of the invention and introduction of correct weighing was the change in the method of trade transactions. In all lines of business, whether of hay, coal, grain or live stock, the old method of measure and count has given way and everything from the minute prescription of some potent drug to the loaded railroad car or the 500 ton gun is now weighed.

Early United States Patents.

No record was found in the patent office of the above scale of Erastus Fairbanks, said to have been invented in 1831. The earliest patent on a platform scale seems to have been to B. Bull, which was issued March 3, 1837. No specifications are on file, but the drawings show at the end of the beam the tray on which weights are placed and also the movable counterpoise, knife edge balance and wooden frame work. One of his scales has four sections. The principles covered by Mr. Bull are shown in Figs. 4 and 5 which are included to show the progress in large weighing up to that time.

The next advance in platform scales, the invention of Elnathan Sampson, which embodied the central shaft principle, is used in a modified degree in three makes of scales on the market today. The specifications of this patent, dated June 25, 1854, are not included here as they were not thought of sufficient importance to justify having them copied. An illustration of this scale is shown in Fig. 6. Most of Sampson's scales were applied to weighing canal boats, the one installed at the Harrisburg Lock in 1849 being the best known.

Even at this early date, however, scales were used in the weighing of railway cars, and in Dec., 1856, a patent was granted to Lea Pusey for what is now called a "dead rail." Describing the invention Pusey says:

"The nature of my invention consists in a peculiar mode of constructing and arranging the rails and platform of a railroad scale in relation to the supports and rails of the main track. A train may pass directly over the scale without injuring or even touching the same, whereby the expense and loss required for placing the scale on the outside of the main track as heretofore is entirely avoided. . . The utility and advantage of my invention consists in the fact that a scale can thereby be combined with the main track of the railroad so as to avoid entirely the outside track for the scale as heretofore required—thus saving in the expense of construction, besides enabling me to place the scale in a position where the room for an outside track cannot be procured. In order to preserve railroad scales from the destructive effects of locomotives and cars in trains passing rapidly upon them it has heretofore been necessary to place the scale upon a siding or outside track constructed for that purpose, and connected with the main track by frogs

2 Sheets—Sheet 1.

B. BULL.

Balance Scales.

No. 133. Patented March 3, 1837.

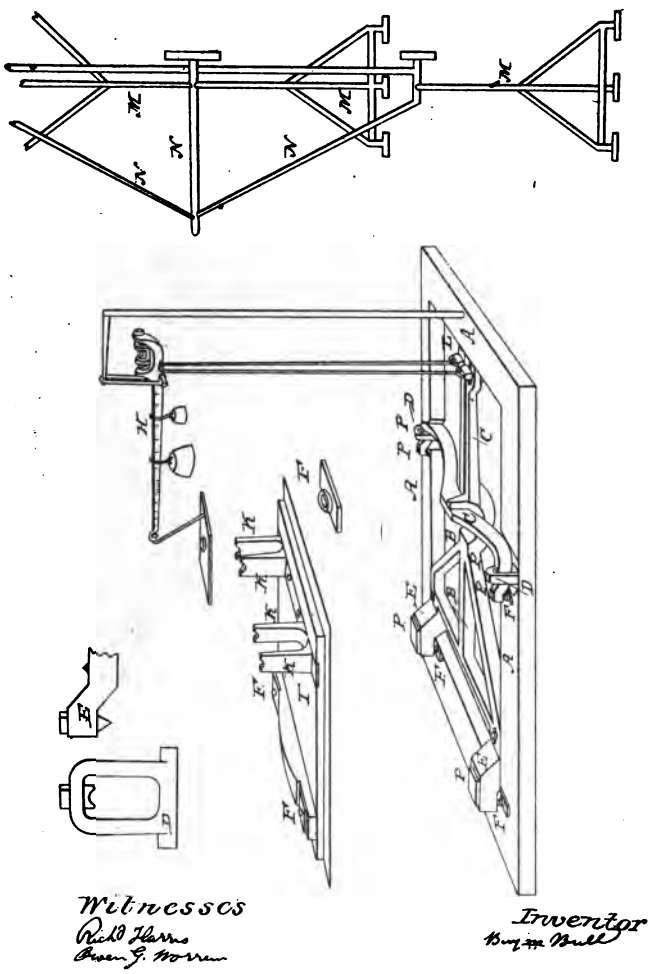


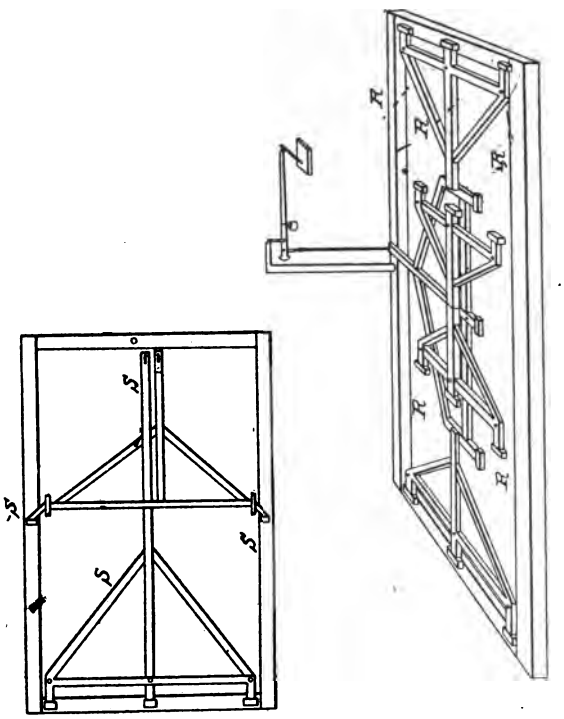
Fig. 4.—The First Two-Section Scale and the First to Use Steel Pivots and Counterpoise.

2 Sheets—Sheet 2.

B. BULL.

Balance Scales.

No. 133. Patented March 3, 1837.



Witnesses
Robt Harris
Asa T. Morrison

Inventor
Byng Bull

Fig. 5.—The First Four-Section Scale.

E. SAMPSON.

Platform Scales.

No. 11,388. Patented June 25, 1854.

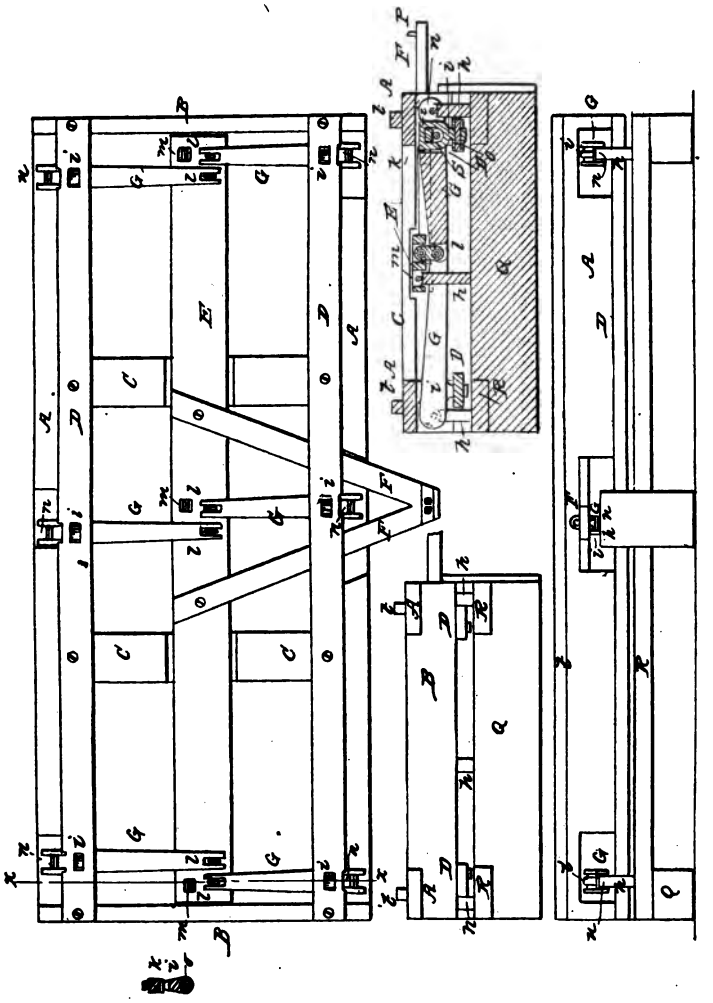


Fig. 6.—The First Scale Using the Central Shaft Principle.

and crossings—involving an expense of about thirteen hundred dollars for rails and cross ties alone, besides the necessary occupancy of ground for the same of about three hundred yards in length and five in width, which latter, in a city especially, it is of great pecuniary importance to avoid, even if it were possible in all such cases to find locations suitable in other respects for the purpose required.

"What I claim as my invention and desire to secure by letters patent is: —The arrangement of the platform of a railroad scale, either in a main or subsidiary track of a railroad, substantially in the manner herein described and set forth—so that when said platform is not in use for weighing as a railroad scale, the locomotive and train may pass directly over the same without bearing upon the said platform or scale, and also so that the cars may be passed on or off the said scale, in the course of weighing, without crossing the track, and therefore without using a frog or its substitute, as described—whereby all the advantages heretofore derived from a siding constructed for preserving the scale from the injurious effects of the locomotives and trains passing rapidly over it, are equally attained; and the room and expense required for the construction and use of the said siding entirely avoided."

This arrangement which greatly resembles the dead rail supports in use at the present time is shown in Fig. 7.

On Jan. 3, 1857, Thaddeus Fairbanks appears as the patentee of a track scale. This patent was reissued in 1874. As described by the inventor it is an improved platform scale for weighing railway cars "either alone or in train." His claims as put forward in the specification are:

"I claim as my invention—

"1. The combination of a series of transverse bearing levers, C C, a longitudinal multiplying lever, E, and a further longitudinal lever, F, adapted to act as both an equalizing and a multiplying lever, substantially as set forth.

"2. The standards, E, extending upward by the sides of the platform, and between it and the sides of the pit, in the manner stated, in combination with the transverse levers, C, suspended therefrom, and with a series of central levers and connections, as herein set forth.

"3. The cross frames or bridges, D, affording supports for the bearings at the sides for the cross levers, C C, and for bearings at the center for a series of levers and connections, to communicate to the weighing beam, substantially as set forth. . . . I am aware that it is not new to employ a series of transverse bearing and multiplying levers, and a multiplying lever confined to a long longitudinal shaft and an arm extended transversely therefrom, the inner ends of the bearing levers being suspended from the shaft at one side of its axis, while such shaft rested on bearings applied to either side of its axis. This is the arrangement and combination shown in the patent of Elnathan Sampson granted July 25th, 1854. My invention not only differs from the latter, but has important advantages over it, as it completely avoids the difficulty incident to the longitudinal shaft, and which prevents the apparatus from weighing correctly trains of varying length and large weights. * * * The bad results of the effect of torsion on so long a shaft as is required to extend underneath a platform capable of supporting a train of 20 or 30 railway cars, renders a weighing apparatus dependent on such a device of little practical value.

"I employ counter sway rods or chains, such as are usually used to prevent injurious longitudinal or lateral swaying of the platform.

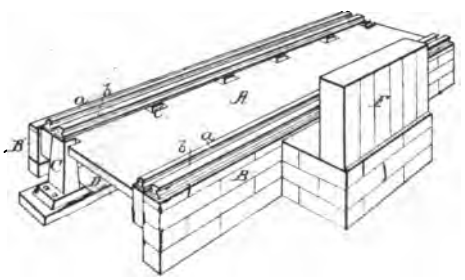
"When my improved apparatus is used for weighing railway cars or trains, its platform is to be furnished with rails, and arranged in line with the railway track, so that cars or carriages of the railway may pass on and off said platform.

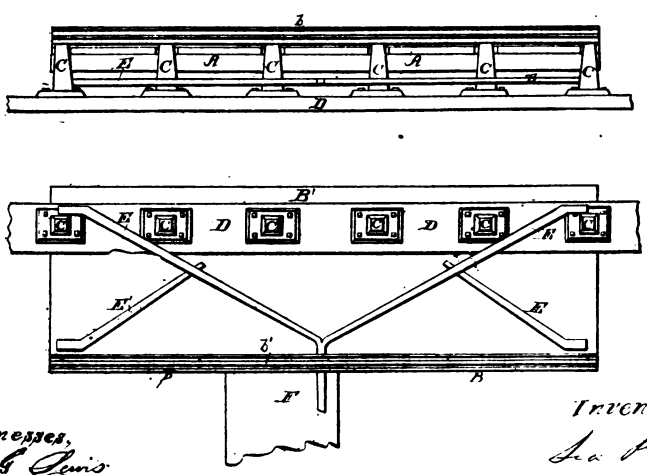
"I do not claim a combination of levers wherein four platform bearing levers are multiplying levers and radiate from one common center, and are

L. Pusey.

Railroad Platform.

No 16,286. Patented Dec. 23, 1856.





Witnesses,
Saml. G. Lewis
Benj. Mussin

Inventor:
L. Pusey

Fig. 7.—The Dead Rail in a Track Scale.

there suspended to a multiplying lever connected with an equalizing lever as I am aware that such is a common method of making a platform scale. Nor do I claim the combination of a multiplying lever, an equalizing lever and an equalizing and multiplying lever, as I am aware that such have been employed and the platform thereof upheld by being made to rest directly on the first and last of said levers. This differs essentially from my combination and arrangement, as by such I am enabled to employ an additional series of levers, viz., the transverse levers, C, C, C, whereby I gain many fold increase of leverage and thus render the weighing apparatus useful for determining the weight of railway carriages."

Fig. 8 illustrates the patent of 1857, and Figs. 9 and 10 illustrate that of 1874. Many of the defects in the earlier scale were corrected in the later patent. It will be noted that the general arrangement of levers of this Fairbanks scale is practically the same as that in use at the present time.

On May 24, 1859, patent was issued to Francis M. Strong and Thomas Ross of Brandon, Vt., for improvements to a track or platform scale, the following claims being made:

"1. Arranging the series of rocking levers which sustain the platform with their shafts all parallel and with the arms all of them in the same line, except those constituting the inner section, which are inclined, substantially as described, in combination with the transmitting lever above, which connects with the scale beam, to the short arms of which they are all suspended at equal distances from the axis of vibration, substantially as, and for the purpose described.

"2. The method of connecting the several sections of the shaft of the transmitting lever by means of projections and links, substantially as described, for the purpose of enabling it to yield freely to inequalities or variations in the supports, that it may vibrate freely and without binding, and thereby transmit the weight accurately to the scale beam, as described.

"3. Suspending the bearing blocks by two links, in the manner substantially as described, so that any swinging motion of the levers will not cause the blocks to vibrate on the knife edges, by which means we are enabled the better to preserve fine knife edges so essential to accurate weighing.

"4. Constructing the bearing pieces with a convex face and projecting tenon, substantially as described, whereby they are rendered self adjusting, that the knife edges may bear without binding, as set forth.

"5. In combination with the nose iron adjustable by a screw in the end of the transmitting lever, the employment of a spring bearing against the end of the adjusting screws, substantially as described, and for the purpose set forth."

Fig. 11 is an illustration of the Strong and Ross scale. It will be noted that this patent shows on the part of the inventors an understanding of the use and abuse to which a scale is subjected and claims 3, 4 and 5 are the first mention of these devices now in general use. These same inventors are said to have devised the ball bearing used in the Howe scale, and which was the first attempt at a shock absorber applied to track scales.

In Nov., 1859, Thaddeus Fairbanks secured a patent on a railway track scale on the pipe lever or torsion principle for which he claimed:

"The arrangement of supporting standards and the loops or supports of the longitudinal levers and platform with respect to each other and so as to extend within or into the space between the side timbers of the platform substantially as specified."

This form of scale appears not to have gained wide use, and its manufacture has been long discontinued by the makers; it is not illustrated.

On Aug. 6, 1867, S. E. Robbins secured a patent on the improvement illustrated in Fig. 12, for which the following claim is made:

"I claim the construction of the knife edge bearings throughout the scale with concave edges fitting upon convex surfaces, as and for the purpose substantially as set forth. . . . This invention is, to some extent, in the nature of an improvement upon the construction shown in R. F. Walcott's patent of Nov. 1, 1859, the improvement relating to the construction of the

T. FAIRBANKS.

Platform Scales.

No. 16,381. Patented Jan. 13, 1857.

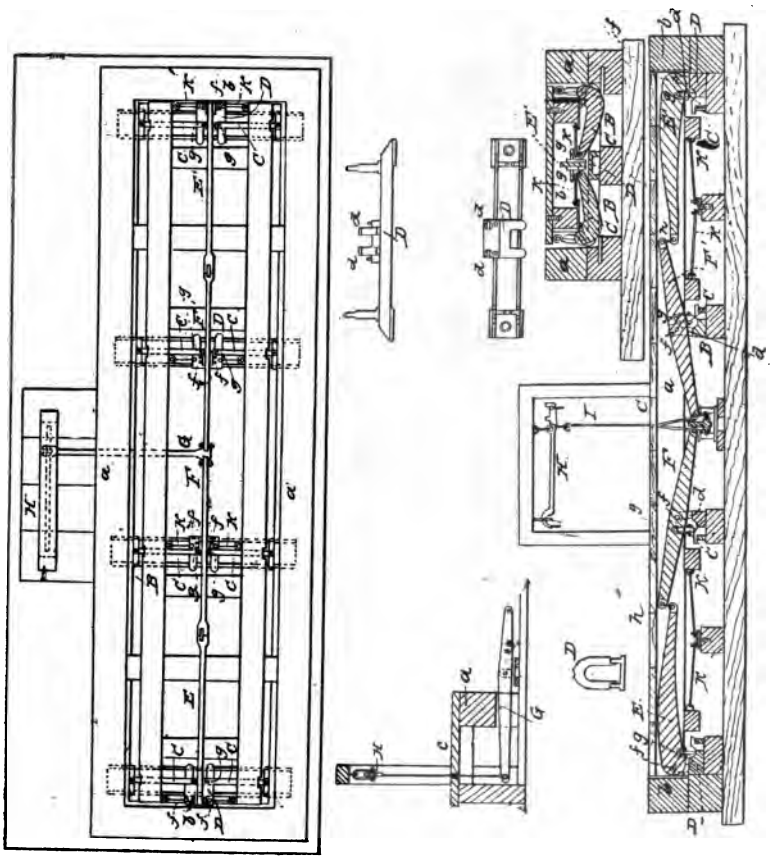


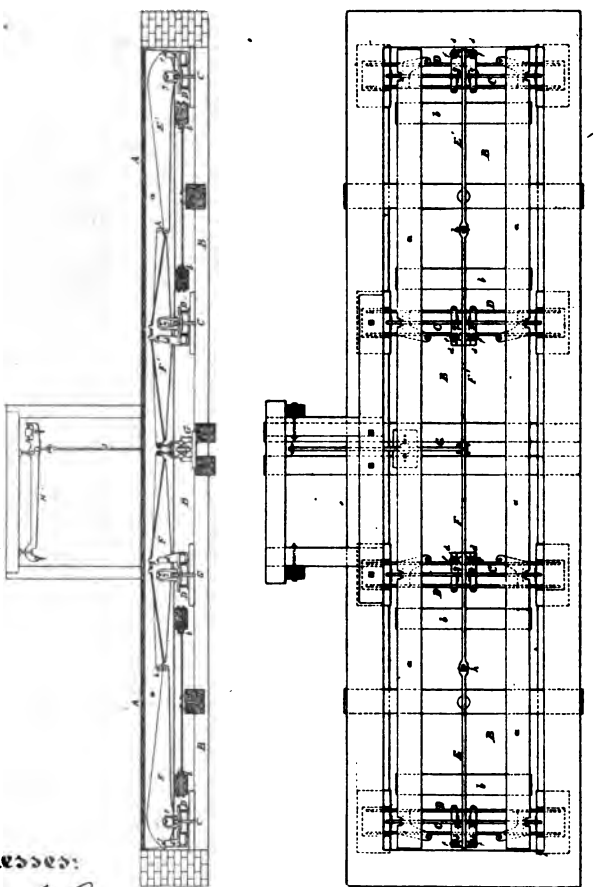
Fig. 8.—The First Scale Using Cross Levers and Central Extension Levers.

2 Sheets--Sheet 1.

T. FAIRBANKS.

Platform-Scales

No. 5,726. Reissued Jan. 13, 1874.



Witnesses:

Arnold Gorman.

Wm. C. Dey.

Inventor: Thaddeus Fairbanks

by his attorney J. J. Slocum

New York Lite

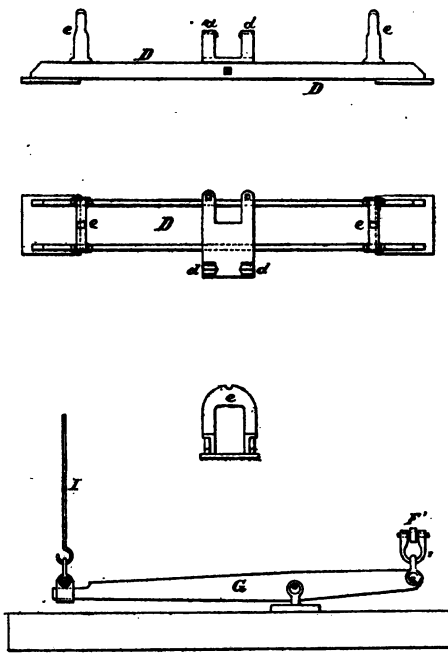
Fig. 9.—The Improved Scale,—Extension Levers Set Level.

2 Sheets--Sheet 2.

T. FAIRBANKS.

Platform-Scales.

No. 5,726. Reissued Jan. 13, 1874.



Witnesses:

Arnold Norman.

Wm. C. Dey.

Inventor:

Thaddeus Fairbanks

by his attys T. D. Stetson

New York Pat.

Fig. 10.—The Improved Link and Bearing.

STRONG & ROSS.

Platform Scales.

No. 24,162. Patented May 24, 1859.

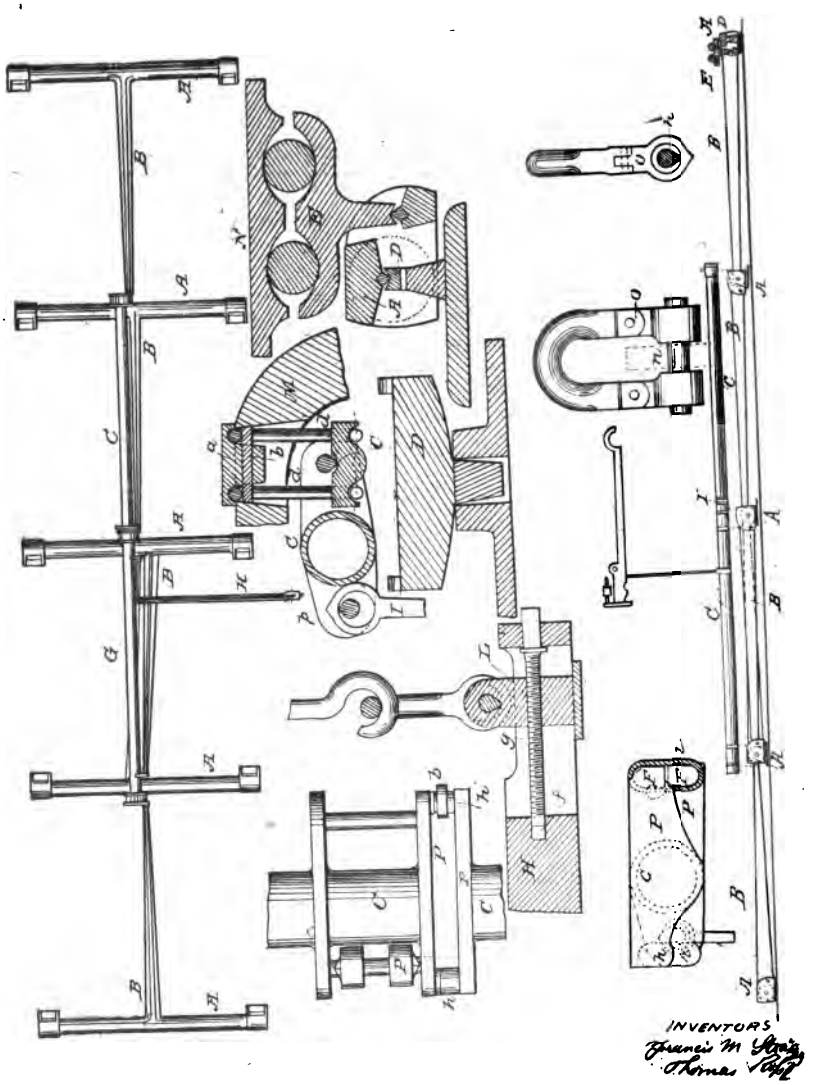


Fig. 11.—The Improved Central Shaft Scale, (Suspended Link, Protected Pivots and Ball Bearings for Absorbing the Shock.)

various movable knife edge and socket bearings, or connections between the scale and the supports of the weight receiving platform, the object of the improvement being to steady the platform, or prevent it from swaying laterally when a heavy body is placed upon it, and to more effectually equalize and centralize the connections throughout the scale. These bearing edges are ordinarily made straight, and rest upon concave seats; and my invention consists in making each knife edge concave, and to rest upon a concavo-convex bedplate or bearing, which, while permitting the edge to rock in a direction at right angles to it, insures a freedom from lateral vibrating sway."

In 1874, John H. Usher, of Buffalo, N. Y., secured a patent on a track scale using a double system of longitudinal levers and no cross levers, and in October of that year Thaddeus Fairbanks secured what appears to be his last patent on an arrangement of levers in a track scale. As neither of these were much used and have altogether passed out of use now they are not illustrated.

A glance at these is interesting as showing how much in error some of the inventors were in their views. Mr. Pusey hoped to make it possible to install scales in main lines, and Mr. Fairbanks expected to weigh whole trains at one time. Yet one cannot withhold admiration from these men whose inventions have been of such wide service.

Introduction into General Use.

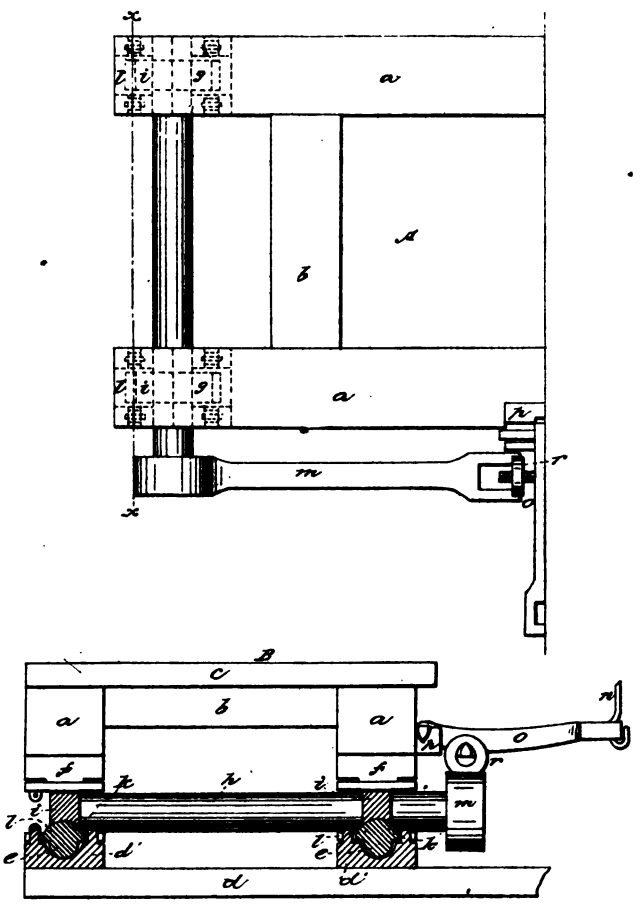
Track scales were in quite common use on what are known as coal roads and which competed with canal boats in the transportation of that article in the 60's, but their use was little known throughout the territory west of Pittsburgh and Buffalo. Here the steamship custom was in vogue. Tonnage on steamships and sailing vessels is largely computed by the space occupied, a certain number of cubic feet being equivalent to a ton. In railroad service the cars of that day were ordinarily 10 ton cars. Those used in transporting coal and ores were very short having but four wheels, and were known as buggies. The box cars were quite small, as were the flats. A common car of that period was the crate car which much resembled the stock car of today, excepting that it had no roof. It was used in the transportation of oil in barrels and the return of the empty barrels. With the introduction of tank cars for this purpose these cars were put in service in moving black walnut lumber from Indiana and Ohio to the eastern states. It was the custom to bill a car by its capacity. If it was stenciled 10 tons, it was so billed.

At that period the railroads were mostly very short lines. Gages of tracks varied, there being some 17 different widths. There was little interchange of cars, the greater portion of the freight being reloaded at transfer points. This gave places which had water transportation great advantage, and with the growing importance of Chicago and its trade, Pittsburgh sought to secure some of the traffic which was going by the lakes and the Erie canal. To accomplish this there was organized by Pittsburgh merchants and officials of the Pennsylvania R. R. what was called The Empire Transportation Company, or as popularly known, the Empire Fast Freight Line. This company built what were called broad tread cars, the wheels of which had a tread that enabled them to travel over the varying gages of track from 4 ft. 8½ in. to 5 ft., making it possible to run a car from Chicago to the Atlantic ports. In order to attract freight from the water routes this line at first accepted freight with guarantees of delivery within certain time. The widely different weight of freight offered was observed, and as a protection to themselves this company installed track scales at Erie and Pittsburgh, their principal points of transfer. It was quickly discovered that freight was being greatly underbilled, and this company weighed and rebilled freight by their weights and collected freight charges for the increased weight and remitted to the consigning road. This refund made by this line to the Lake Shore and Michigan Southern railroad for the first year was over $100,000. Such lessons were not to be ignored, and the installing of track scales spread rapidly.

S. E. ROBBINS.

Platform Scales.

No. 67,454. Patented Aug. 6, 1867



WITNESSES.

J. B. Hilder.

M. W. Bellingham

INVENTOR.

S. E. Robbins by

Crosby Hadden & Gaylo Atty

Fig. 12.—The Concave Bearing. (The convex knife edge was early abandoned.)

It is related that as a group of railroad officials of that time were walking down Broadway one day they passed the agency of a scale company which had a window display. One of these men dropped on his knees, turned his eyes upward and began to move his lips. His companion upon missing him, looked around and saw him the center of a gathering crowd. Hastening back he asked, "Charlie, what is the matter?" Opening his eyes upon rising he answered, "Tom, after the money those track scales have made us, I cannot pass one without saying a prayer."

Report on Track Scales, 1874.

The Empire Line introduced a system of having annual meetings of its officers and employees, and at the annual meeting held at Kane, Pa., Sept., 1874, an extended report on track scales was made. The question arose concerning a proposition to guarantee the weights at destination as determined at point of lading. As this was the earliest scale committee of which record is found, the following extracts from the report are made:

"That the present system of track scales can be made absolutely correct for the requirements of them, your committee do not at all believe; but they do believe that by a proper system of testing and regulating, together with the greatest care exercised in their preservation, the delinquencies of scales may be very much reduced.

"Your committee have already intimated that the present system of testing track scales is in many respects defective; and after a limited consideration of the subject they would recommend the following changes in the plan of testing scales: Two short cars, similar to those now in use for the purpose, weighing, say about twelve tons each, their exact weight to be carefully ascertained, should be used in testing each track scale, thus insuring that the scale shall be tested nearly if not quite to its full capacity. These test cars should be transported from point to point, not under any circumstances upon their own wheels, but upon a platform car specially prepared for that purpose, with such appliances as may be necessary for the convenient taking on and off the test cars. The present system of transporting test cars from place to place upon its own wheels, your committee consider very reprehensible, as such movement cannot fail to more or less depreciate the previously ascertained weight. In testing a scale, one of the cars should first be run on the scale, and the weight tried, in the middle and each end of the platform; or, in very long platforms, the car should be placed over each set of bearings, and its weight tried at the several points; this to test if all the bearings are working uniformly and correctly. The variations from the correct weight, if any, at each point should be carefully noted and recorded. Both test cars should then be run on the scale, and the variation of the scale, if any, from the correct combined weight of the two cars should be noted and recorded. Any variations developed in the above tests should be adjusted and corrected by the scale tester at the time, if within his power; but if the cause of the defect is not immediately remediable, the parties in charge should be notified not to use the scale until such a time as the scale tester shall pronounce the scale correct and authorize its use.

"The tester should make regular reports to the properly authorized officer, giving the differences found in each scale at each testing; and it should be his duty to carefully investigate the causes of the differences, and state fully in his report his opinion of the causes of such differences, and the reasons why the scale does not continue to work correctly after being once adjusted by him. The tester should always carefully examine all parts of the scale each time tested by him, even to the weighing beam and poises, whether he finds the scale correct or not; and his report should give the result of such examination, particularly as to the conditions in which he found the working parts of the scale beneath the platform, and the scale pit itself, and all parts of the scale ordinarily hidden from observation and consequently liable to be neglected by those in charge. Too much can hardly be said of the importance of having the testing of the scales thoroughly attended to; and to that end,

the scale tester should be a man of unquestionable competency for the position, and fully impressed with the importance of his duties.

"Before leaving the subject of scale testing, your committee desire to state that, in their investigations, they have examined and tested scales of all the principal makers, and have found the various delinquencies of each so nearly equal to the others, that they have refrained in their report from specifying the make of any scale to the preferment or detriment of others; and such being the case, your committee believes it very essential that the regularly appointed tester be solely in the employ of the road, and that he be altogether free from any prejudices in favor of or against any particular make of scale.

"Weighmen or parties in charge of scales should make frequent and thorough examinations of the pit and all the working parts of the scale; be sure that the pit is kept free from water, dampness, or accumulations of dirt. The scale pit should be aired as frequently as possible, to prevent dampness therein. Particular attention should be given to the condition of the knife edges and bearings of the scale; and by means of a small brush they should be kept perfectly clean and free from any obstruction. This matter of looking after the condition of the scale, as to cleanliness, your committee believes cannot be too strongly required of the parties in charge of the scale; and evidence of neglect in this particular should be immediately reported by the scale tester, both to his superior officer and to the parties in whose particular interest the scale is employed. As every jar the scale receives, and every car that moves over the platform, wears the knife edges and working parts of the scale, we recommend that those in charge of scales be instructed to allow nothing to pass over the scales excepting what is to be weighed, and under no circumstances whatever to allow a locomotive to pass over the platform of the scales.

"Your committee believes that with all the defects inherent to track scales as at present constructed, their inaccuracy is greatly increased by neglect and rough usage, and that such neglect and rough usage can be stopped by the enforcement of a rigid discipline in all matters connected with the using of track scales.

"To this point your committee have only considered the irregularities and deficiencies of the scales, and the means employed to adjust them and continue their accuracy, and believe they have detected much in the construction and maintenance of them to condemn. It would, however, be unjust to attribute all the defects and shortcomings of the present system of determining weights to the scales, and not take into consideration the fact that inevitably much must depend upon the care and accuracy of the weighman using them, in order that the greatest possible correctness be attained with the scales, even as at present constructed. The weighman should in all instances be a reliable and very careful man,—one who is thoroughly conversant with the nature of the construction of the scale he is using,—well posted on all its weak points and inaccuracies, and should personally see that his scale is at all times in the best possible condition to do the work required of it. Weighmen should be thoroughly impressed that approximate accuracy is not what is expected, but as near as possible—absolute accuracy.

"The following rules will govern this company in respect to its own scales, and will be submitted to the owners of other scales that are used to determine weights guaranteed by us:

1. Scales will be set up in the manner that the maker states to be necessary to secure accurate results; care being taken to see,—

(a) That foundations are solid, inelastic and permanent.

(b) That scale pits are well constructed, properly ventilated, and have loose plank covering their entire length, so that they can be readily exposed to view throughout.

(c) That proper protection from the weather is secured.

(d) That a location is had where the scale will be protected from any passage of cars, except in weighing, and that locomotives do not cross scales that are designed for accurate weighing.

2. Respecting the maintenance, testing and use of scales,—

(a) Call will be made on scale makers to furnish instructions for the care, adjustment, testing and use of their scales, and such instructions will be printed and posted in plain view at each of their scales in use by this company.

(b) A thoroughly competent inspector of scales will inspect, test and adjust all scales at least once a month, and more frequently if practicable, and will make special inspections and tests at any time on call of weighman or owners of scales. He must personally examine all parts of each scale he inspects and the full detailed results of each inspection or test must be recorded by him in a record book kept at the scale and understood by the weighman; a full report must be also made by him to the proper officer. He will have power to condemn defective scales and order any necessary repairs, reporting such action to the proper officers.

(c) Weighmen will be examined and instructed by the inspector of scales, and appointed and retained only on his recommendation. They must uncover the scale pits frequently, and see that the working parts of the scales are clean and in good order. They must record in a book kept at the scale, for examination of the inspector of scales all facts of interest respecting the condition and working of scales.

(d) Scales will be tested to the full weight to which they are expected to work, and corrected when necessary to secure strict accuracy. Frequent testing is necessary.

(e) To avoid depending on the judgment of the weighman to determine the proper play of the beam, a pointer will be placed on the end of the scale beam, traversing a vernier, which will accurately indicate the play of the beam."

The committee also condemned much of the scale practice of that day, but as modern scales have devices to reduce wear on the knife edge and the other defects are now remedied, space is not given to these recommendations.

Some of the committee's recommendations (above named) have particular interest today. Their recommendation as to test cars when read in connection with the recent circular of the Bureau of Standards on the same subject makes us wonder why so little consideration has been given to accurate testing.

Developments of Track Scales, 1870-1890.

There were but slight changes in track scales for the 20 years preceding 1890. The 25 ton scale with a 24 ft. platform was succeeded gradually by the 50 ton scale with a 30 ft. platform. Some of the latter were by use of the stencil made into 60 and 70 ton scales. Some were also made into 32 ft. platforms by increasing the overhang of the scale bridge or girder. In the scales of the Fairbanks type it was thought unsafe to use over a 10 ft. span, which was the length in most common use, and the makers of the Sampson type of scale were advertising scales of any length or any number of multiples of 10 ft. after the first. The first section was 12 ft., and they advertised scales of 12 ft., 22 ft., 32 ft., 42 ft., etc., in length. As the cars for special purposes began to be built too long for the 30 ft. scale the makers of the Fairbanks type began to add another section, using the equalizing lever for that purpose, and merely adding another section without changing levers or other parts. The scales of that period had shallow pits and were mostly built on timber foundations with little attention being given to drainage; and, as but little skilled labor was used in their installation and inspection, these scales failed to give entire satisfaction, from which a prejudice was established against the five section scale that is still a handicap to its use.

It seems proper that the two types of scales should be referred to by the names of their inventors; all scales using the central shaft and torsion principle to be called the Sampson type, and all scales using main cross levers and central extension levers to be termed the Fairbanks type.

As adding to the historical interest of this report and to increase its educational value there are shown three of the scales of that period. By showing

these it is hoped that the discussion farther on will be more readily understood.

Fig. 13 shows a Howe scale installed for the New York Central about 1870. As will be seen it was 42 ft. long with a pit but two feet deep. It was called a "heavy scale," and its rated capacity was 40 tons.

Fig. 14 is an end sectional view of a Fairbanks type of scale of that day. Fig. 15 is a side sectional view of a similar scale with four sections. Fig. 16 is a similar view of a five section scale of this type. Our attempts to secure views of actual scales of this type, or drawings of them, have been unsuccessful.

(Figs. 13 and 16 have been omitted.)

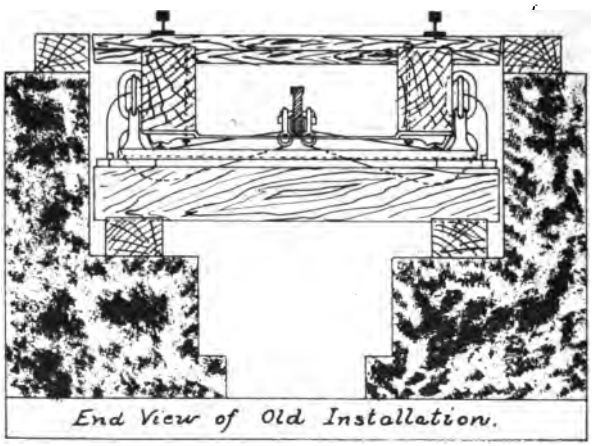


Fig. 14.—End Sectional View of Early Fairbanks Type.

After the unsatisfactory behavior of the five-section scale of the latter type became apparent several of the railroads began making independent investigations into the question, and such use as had been made of steel I-beams in place of the wooden timbers in the scale bridge were carefully considered from a scientific standpoint. Strife arose between the scale companies (who urged that they knew their business) and the dissatisfied roads who showed the unsatisfactory work. Out of this grew several marked advances by the roads and many similar advances by the makers. It seems also that from about 1890 dates the entrance of educated mechanical engineers into the service of the scale companies. With the entrance of some roads into making their own scales came the advances which are next considered.

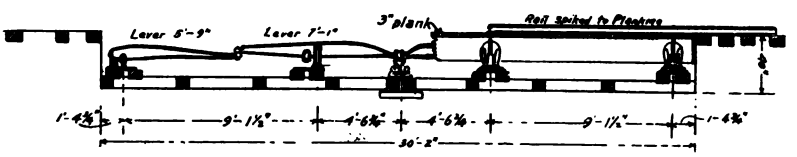


Fig. 15.—Longitudinal Section Fairbanks Type, 4-Section, 30 Ft. Scale.

Commercial Scales of Today.

The Sampson type has no cross levers, but has instead round levers which transmit the load to the extension levers by torsion. The main or extension levers do not connect and transmit their load from one to the other but to a longitudinal shaft parallel with and slightly offset from the extension levers as shown in Fig. 17, which illustrates the Howe scale. The Howe Scale Co. makes the largest number of this type of scale, although other

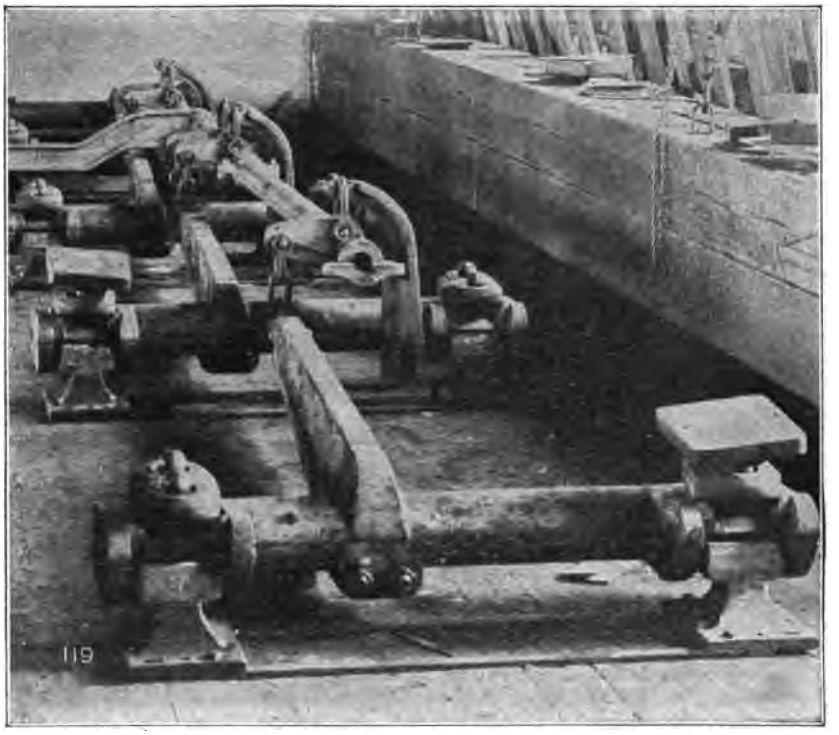


Fig. 17.—Showing the Principles Embodied in the Howe Scale.

makers use some of the same principles. Fig. 18 shows the arrangement of ball bearings and knife edges of the round lever by which the torsion is set up and transmitted to the extension levers. By the use of the longitudinal shaft, shown in Fig. 17, any number of sections might be installed without

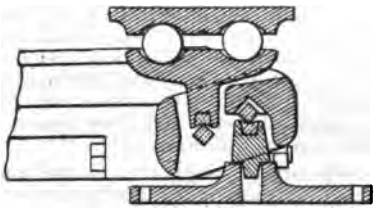


Fig. 18.

other objections than the length of the shaft and the lost motion incident to the torsion. In Fig. 17 some of the bearing plates for the weigh bridge are shown in place and some are removed, the balls under the plates being shown. These balls relieve the scale mechanism from the shock and jar arising from the motion of the weigh bridge. The strong points of this scale are its simplicity, its few parts, its ball bearings, the length of knife edge it is feasible to provide and the perfect support it is possible to give the knife edge by covering its entire length with the casting. In spite of its simplicity this type has not met with the popularity of the Fairbanks type.

Fig. 19 shows a combination of the two types, as embodied in the Winslow scale, in which the round cross shafts are retained and the central or longitudinal shaft is dispensed with, a more detailed view of the round

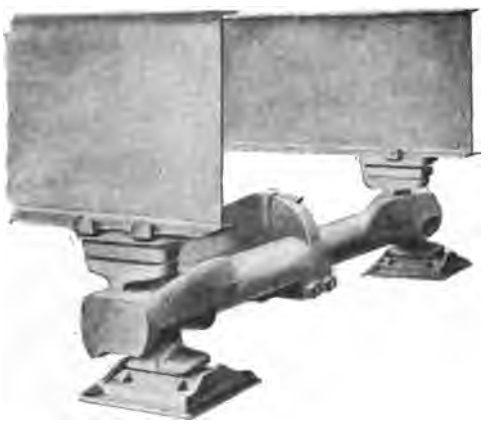


Fig. 19.—Principle of the Winslow Scale.

lever bearings being shown in Fig. 20. In this type or make, steel rollers are used in place of the steel balls of the Howe scale.

The Fairbanks type system of levers consists of sections, each comprising a pair of main levers which run at right angles to the track. The sections are spaced to suit the length of the scale platform, and there are usually four or more. The load is transmitted to the main lever bearings which are attached to the girders, is then carried to the extension levers, running parallel to the track and connecting with one another to the center of the scale or butt of the fifth or transverse lever which transmits the load to the beam. Fig. 21 shows a four section arrangement of levers. The objective sought by all scale designers is to introduce such design as will permit the load to be transferred to the weighing platform with the least disturbance to the scale mechanism, especially the delicate knife edges.

In the earlier designs, as shown in Fig. 21, the main levers were suspended from cast iron yokes by means of loop A and link B, which permitted the main levers to swing with the platform. In all scales there must be a certain amount of lateral motion to the weighing platform, due to the longitudinal thrust of the load passing upon it. This motion is usually checked within certain limitations by check rods. When the load moves on to the weighing platform the entire platform and levers move together within their limits and return to their original position.

The main lever knife edge C is parallel to the track, or thrust, and in actual practice the original position of the lever and position is not maintained exactly, but the platform bearing will move slightly on the knife edge, due

G1.– Bottom Plate, which rests on the foundation.
G2.– Roller between bottom plate and G3.
G3.– Lower bearing, which has the sharp edge of the pivot (these pivots are located in the ends of the round levers), resting on it.
G4.– Upper bearing, which rests on the sharp edge of the pivot (these pivots are also located in the ends of the round levers)
There are also 8 upper bearings. Resting on the 8 upper bearings, G4, are 8 in. rollers.
G5.– Middle plate.– 8 of these, which rest on the 8 in. rollers and are provided with 2 roll-ways in their upper surface that receive 16 4in. rollers.
G6.– Top plate.– 8 of these which rest on the 16 4 in. rollers and directly support the platform timbers, or steel beams.
This combination forms the protected bearings which protect the sharp edges of the pivots from all scraping motion and wear.
The Rear Levers are bolted to the round levers at each end of the scale.
The Short Levers (2), are bolted to the intermediate round levers and attached to their loose ends to the yoke connecting levers by means of a nose iron, a clevis, a link, a yoke and two stirrups.
The Connecting Levers,– one on each side of the cross lever – rest on the two stands G12, and form the connection between the rear levers and the short levers and cross lever.
F13.– Nose Iron, which is supported by beam rod. This nose iron is bolted on to the cross lever.
G14.– There are two of these – one attached to each free end of the two rear levers.
G15.– Nose Iron. There are four of these attached to the four ends of the connecting levers by means of bolts and set screws.
There are also two adjustable connections between the inner end of the cross lever and the two connecting levers.
These connections are attached to the nose irons G15.

Fig. 20.—The Winslow Scale,—Longitudinal Elevation.

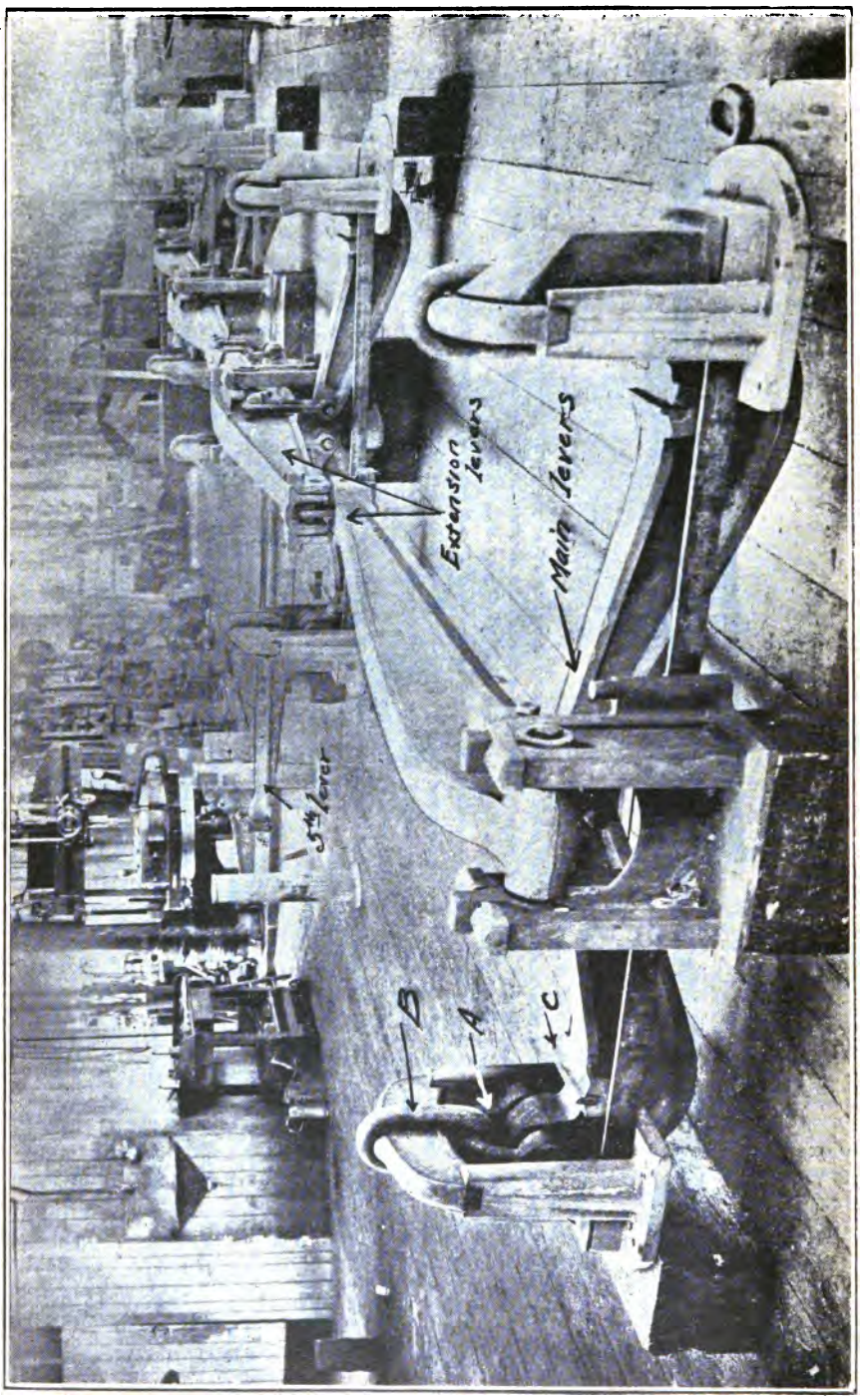


Fig. 21—Showing the Four-Section Arrangement of Levers.

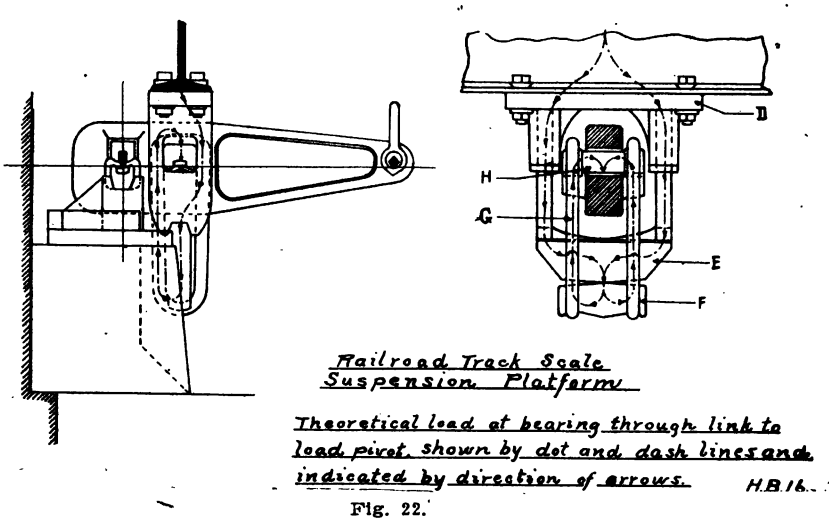


Fig. 22.

to impact and thrust. Even if this movement is only slight, it causes wear on the main knife edge, which is proven in actual practice, as the knife edges show wear before any other part of the scale mechanism, and are the first

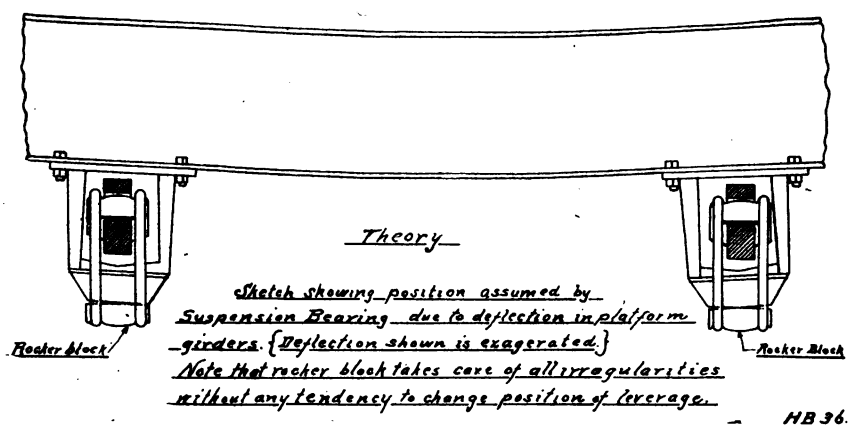

Theory
Sketch showing position assumed by Suspension Bearing due to deflection in platform girders. {Deflection shown is exagerated.}
Note that rocker block takes care of all irregularities without any tendency to change position of leverage.
Rocker Block
Rocker Block
HB 96.

Fig. 23.—Rocker Blocks.

to become defective. A considerable weight, say a sad iron, may be placed on the edge of the blade of a pocket knife without dulling it, provided it is not placed on it with a shock and remains motionless; but move this weight ever so little either across the blade or with it, or drop the weight very

slightly upon it and the edge is gone. Recalling this, it is easy to see why the old installations, as shown in Fig. 21, soon became sluggish and unreliable and why switching across the scale is so harmful. To overcome this fault has been the effort which has done most to improve this type of scales in the past decade, the first improvement consisting in the installation of a flexible support between the weigh bridges and the knife edges.

E. & T. Fairbanks & Co. have introduced what they call a "pendulum support." In this case the scale levers and supports are in a fixed position. the design of the suspension bearings permitting an absorption of all lateral motion before it reaches the main levers. The application of a load to this lever is illustrated in Fig. 22. The load is transmitted through bearing D to cross bar E, into rocker block F, through links G and up to bearing block H resting on the knife edge of the main pivot. The function of the rocker block is to allow for any unevenness in the bottom flange of the girder of the weigh bridge, or to take up the deflection which occurs as shown in Fig. 23. The rocker block and the cross bar are usually made of steel castings.

The length of the knife edge has been materially increased in the more recent designs and an uninterrupted bearing for its entire length has been secured. The difference between the old and newer practice is shown in Fig.

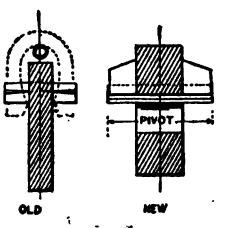


Fig. 24.—Old and New Practice of Inserting Knife Edges.

24. The old style pivot of square steel projected each side of the lever supporting the load by the link. The bearing edge must be hardened to endure the wear, and the main portion must be left in its original condition so as to carry the load. Owing to the difficulty of controlling the hardening of the proper area of the edge, many were made too brittle and broke in service. In the newer type the pivot is only a piece of steel giving a wearing edge, the section of the lever directly under it taking the load.

Fig. 25 shows a four section Fairbanks scale of the newer type. Stand J is machined out to take circular block K; pivot L has a bearing the entire length; block K is made movable.

The Buffalo Scale Co. has introduced what they denominate their "suspension bearing" type where the main levers are supported by chairs so that all levers are practically motionless while the platform is allowed to swing. Their system is illustrated by Fig. 26, Fig. 27 and Fig. 28, which are so clear as to need but little explanation. It is very simple, consisting of but four parts. Their claim is that through its center-connected bearing the one heavy square-topped steel link of 2¼ in. stock with reinforced corners sustaining the load, makes an equalizing lever or rocker arm unnecessary, as is the case when two links are used. The single link allows the platform to swing freely longitudinally as well as transversely. The bearing pivots in this suspension type are 10½ ins. long and have a bearing their entire length. The fulcrum pivots resting on their chairs are 2⅛ ins. square and 10 ins. of pivot edge carries the load at that point.

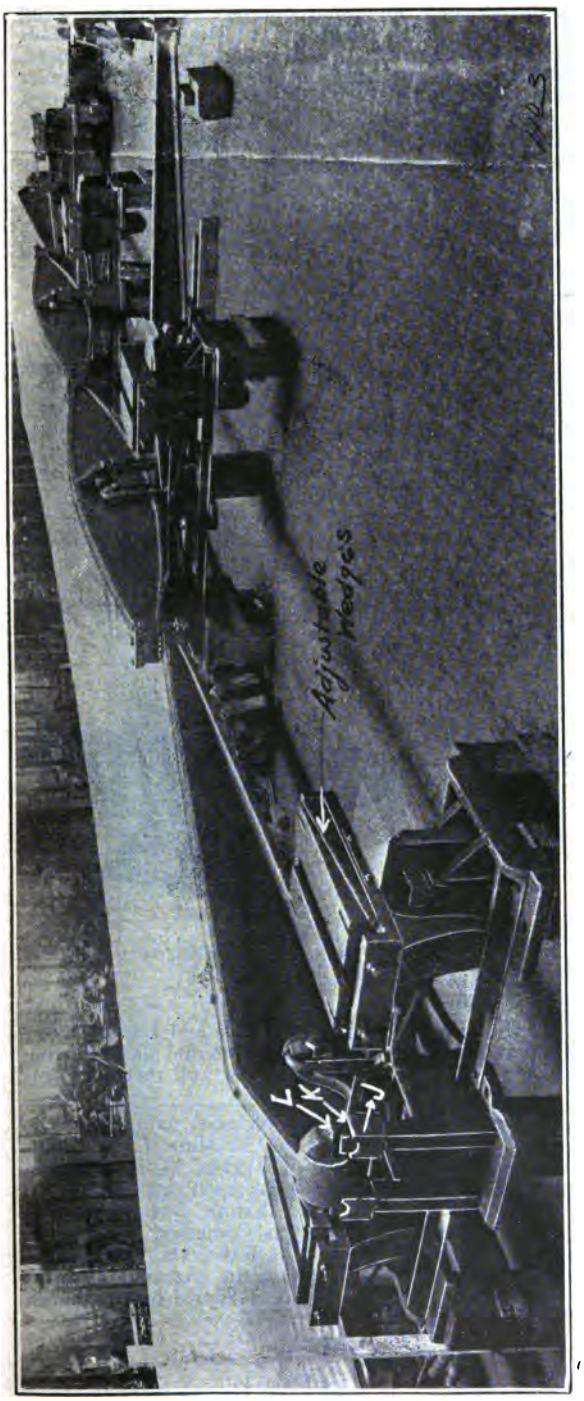


Fig. 25.—Four-Section Fairbanks Scale of the Newer Type.

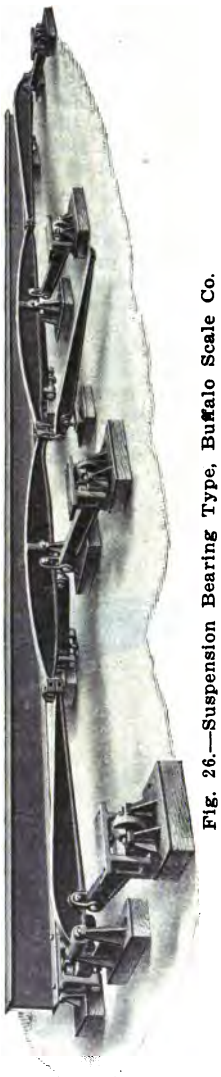


Fig. 26.—Suspension Bearing Type, Buffalo Scale Co.

The Strait Scale Co. introduces a somewhat different installation, using high standards to support the rail and placing the levers lower in the pit. This is shown in Fig. 29, which also shows their suggestion for a rain guard. Little description is needed to this or to Fig. 30, which shows their main lever stand and suspension bearing. As the latter has some noteworthy features, it is shown in outline in Fig. 31. M L is a section of the main lever casting at the knife edge; K is the knife edge, showing the bearing, and S is a removable steel compensating bearing block. As will be noted this is located in a recess in bearing foot B and rests on the knife edge. The curved base of B assures the fit of the knife edge and the projecting ends A A prevent shifting. The four links L L carry the load to the bearing frame F which supports the I-beams of the weigh bridge. Owing to this arrangement of protecting the knife edge against shift, check rods are eliminated from this scale, the shift of the weigh bridge longitudinally being taken up by a bumping block at each end of the scale pit.

The construction offered by the Standard Scale Company is shown in Fig. 32. The design for suspending the platform and adjusting it to minute variations in construction is accomplished by vertical U-bolts and nuts, steel beams and an unfailing support at all points. A cross section shows a closed parallelogram in which the vertical sides absorb the weight and impact, the 12 in. I-beam ties under the weigh rail form the third closing side, and the 6 in. beam ties near the bottom of the pit complete the parallelogram and seals the entire construction. The cast iron blocks interposed between the 24 in. and 12 in. I-beams and the weigh rail give clearance between the live and dead parts of the scale. These blocks are furnished to fit the gradient when the scale is to be set on one. At the same time they serve as lateral ties to the compression flanges of the 24 in. beams at the extreme fiber of the beams. The figure shows the various details clearly and is so readily understandable that no further description is necessary.

Fig. 27.

Fig. 28.

Suspension Bearings of the Buffalo Scale.

Fig. 33 shows an end view of a suspension frame scale and Fig. 34 shows a skeleton frame of a similar scale. One has a steel frame and the other has one of wood. These are made by all the scale companies, and therefore only one is shown.

In preparing the foregoing the committee has received valuable assistance from A. Bousfield, R. W. Romig, L. Norvell, O. B. Main, C. B. Smith, T. L. Richmond, E. Motchman, H. O. Hem, W. M. Welsh, M. H. Winslow and Geo. W. Ristine, and takes this occasion to thank each one for the assistance rendered. This is especially due to Mr. Ristine, one of the few surviving officers of the old Empire Transportation Company, who kindly placed at our disposal the account of the meeting at Kane, Pa., from which the extracts included herein were made. For some of the engravings we are indebted, in addition to the foregoing, to the Industrial World of Pittsburgh, to whose publisher we also return our thanks.

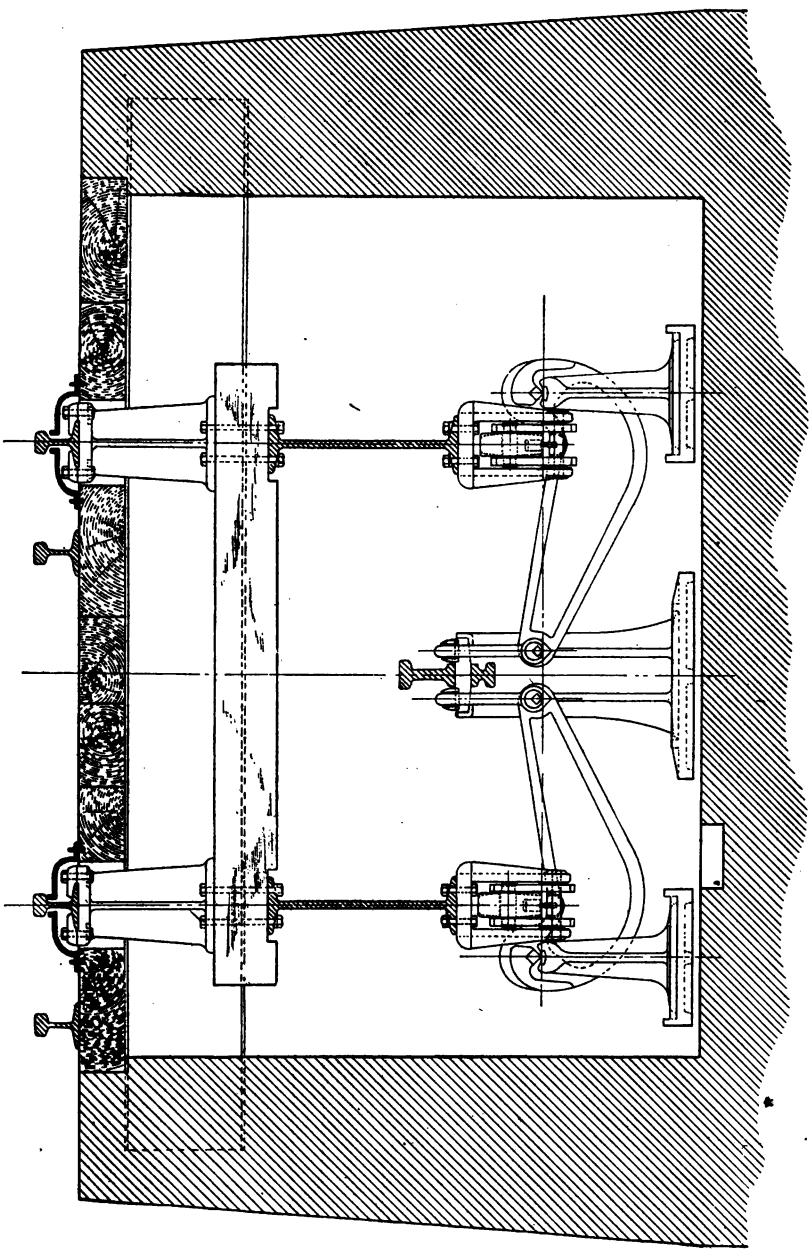


Fig. 29.—Cross Section of Strait Scale (Showing Rain Guard).

Fig. 30.—Suspension Bearing, Main Lever and Stand, Strait Scale.

The Importance of Track Scales.

To the members who have read thus far the thought may have arisen as to why so much space is being given to a subject which may seem to many to consist of nothing more than a pit with some castings in it. For the information of those the following figures are submitted:

Taking the number of track scales owned by roads having one tenth of the mileage and one eighth of the freight cars in the United States and figuring proportionately, there were 3,012 track scales in the country owned by the railroads the first of this year.

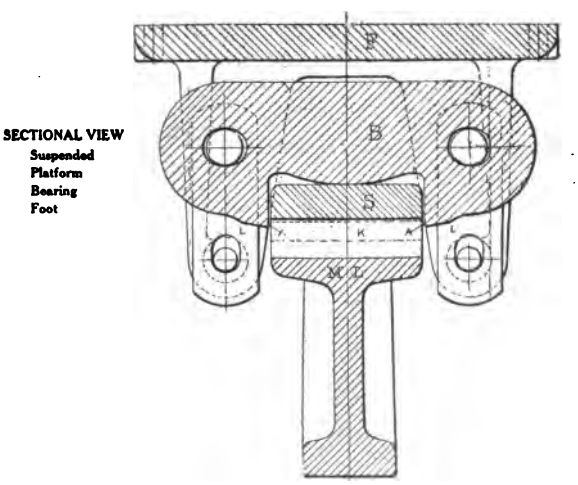


Fig 31.—Section of Suspended Platform Bearing Foot, Strait Scale.

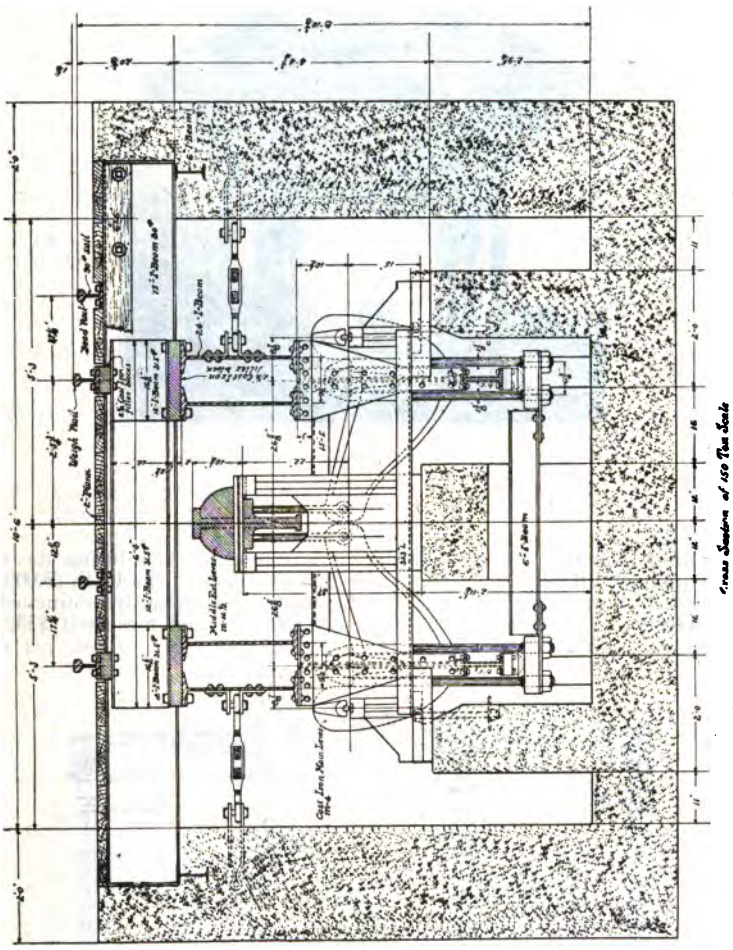


Fig. 32.—Cross Section of 150-Ton Scale, Standard Scale Co.

Fig. 33.—End View, Suspension Frame Scale.

Taking such data as are available, it is estimated that during the year ending June 30, 1912, there were moved by the railroads of the U. S. 25,000,000 cars loaded in carload lots. The freight charges on these are estimated at $1,000,000,000. Each track scale weighed 8,300 cars and measured $332,000 of revenue. If the scale weighed this amount one tenth of one per cent

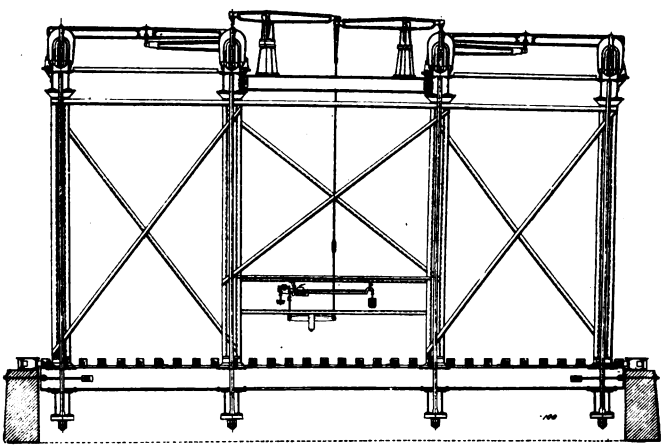


Fig. 34.—Skeleton of a Suspension Frame Scale.

under the actual, the road owning it was loser to the amount of $332. If a scale weighs a car weighing 32,000 lbs., and its contents weighing 40,000 lbs., 150 lbs. less than the actual weight it is giving more than double this error. If it weighs such cars 400 lbs. short it gives a loss of revenue of one per cent. This will pay for an average scale every year and for a very high class scale every two and a half years. The cost between a faulty installment and a good one is about half this estimated possible yearly loss. Ask your scale inspector how the scales on your road average!

Cost of Track Scales.

Mr. F. D. McKenna, of the Pennsylvania R. R., stated in his testimony before the Interstate Commerce Commission in April of this year (1912) that the scales of that company cost when installed $20,000 each.

It is understood that the new scales of the Norfolk & Western were bought in a lot of eleven, the minimum order which the makers would accept, and that the cost of scales and weigh bridge without installation was $7,000 each.

The following costs were furnished us by the roads named:

Florida East Coast, 100-ton 40-ft. scale:

Excavation, 90 cu. yds.,	$ 27
Concrete, 55 cu. yds.,	440
Timber and lumber, 4,000 ft.,	100
Moving and setting scale,	50
Grading, laying and surfacing track,	268
Track and switch ties,	170
Other track material,	342
Engineering,	10
Scale,	1,000
Total,	$2,407

(The above is on a pocket track without dead rail.)

Cost of 46-foot 100-ton scale on L. S. & M. S.:

Excavating,	$ 40
Concrete work and material,	250
Scale complete, including I beams,	696
Platform and beam box,	76
Hardware,	18
Labor erecting,	120
Drainage,	60
Total,	$1,260

Cost of Santa Fe standard scale at Temple, Tex.:

Scales,	$1,472
Other material,	506
Masonry, including excavation in rock,	1,250
Miscellaneous labor,	147
Labor erecting scale and scale house,	430
Total,	$3,805

Cost of Santa Fe standard scale at Los Angeles, Cal.:

Material.		
Scale, and 5,100 lbs. structural steel,	$1,325	
Other iron and steel,	230	
160 bbls. cement,	160	
75 yds. crushed rock,	75	
Piling,	180	
Mill work, etc.,	241	
Graphite and paint,	37	
Hardware, etc.,	115	$2,363
Labor.		
Excavating,	$ 50	
Driving forty piles,	140	
Installing scale,	1,000	
Electricians,	35	
Building scale house,	75	
Painting scale,	35	1,335
Total, material and labor,		$3,698

200-ton 67-ft. scale on P. & L. E. at Glassport, Pa.:

Concrete foundations,	$1,101
Excavating scale pit,	334
Sewer,	181
Steel frame,	3,059
Scale,	2,000
Rails and track work,	565
Placing frame and scale,	548
Engineering and inspection,	264
Electric light wiring,	20
Total,	$8,072

What a Track Scale Should Be.

"A track scale is both a bridge, over which heavy loads are carried, and a delicate mechanism by which a large portion of the revenue of a railroad is measured."

There are three essentials to a track scale: design, capacity and length.

It is not the province of this association to delve into the details of the design of track or other scales, but it is within our province to discuss the more important elements of design, such as the desired sensitiveness, the number of sections, etc., and it is to this end that our attention will be given.

Observation of all types and makes of track scales in various parts of the country leads to the belief that it is a mistake to secure too great a measure of refinement in the track scale. In our boyhood we sometimes owned a pocket knife on which we could put an edge that would cut a hair. If we tried to whittle a hickory stick with this blade the first cut turned the edge and we could not whittle. The edge on a cold chisel is quite blunt, yet it cuts what is intended as no keen edged knife would. A balance is made for the use of assayers which it is said will show the difference in weight of a sheet of paper before and after a name has been written upon it. A track scale which would do this would have its bearings ruined the first time a car was stopped upon it. Correspondence with some and talks with others who have had experience leads to the opinion that if a scale is graduated on the secondary beam to weigh fifty pounds, and is sensitive to half this amount when new, much better results will be had than if greater sensitiveness is sought. This is empirical but has a basis derived from tests on the wear of the knife edges

of several scales. When a scale knife edge breaks or wears it destroys the multiplication at that point and produces a constant error. The American Railway Association recommends that the sensitiveness of scales should never be greater than 100 lbs., and when the scale is new should not be greater than 50 lbs.

A general rule used by the chairman is that in checking weights of cars, as of one scale against another, an allowance of 200 lbs. should be made. That is, if the weight is 100,000 lbs., 99,800 lbs. or 100,200 lbs. should be considered as a check. On one occasion a string of seven cars were weighed with another string acting as a break against a strong wind and then check-weighed with the protecting cars removed. An average difference of 180 lbs. resulted. Wind is a varying factor. With a scale sensitive to 50 lbs. a trifle may cause it to weigh in either of two notches.

Here the chairman wishes to assume the responsibility of saying, after tests of more than 30 track scales, that he considers that every one of the makers named in the first part of this article can build a good track scale and one which will give good results if it be properly installed and handled. To substantiate this he submits the following tests with stock scales of the various makes, each of 100 tons rated capacity, and as near as may be 50 ft. scale rails. By stock scales is meant those of the maker's own design and built to his own specifications, or bought out of stock. The test was to weigh a number of cars by hand and then to weigh them in motion with a Streeter-Amet recorder taking the weight. Of those in the table below the first column gives the number of cars weighed, the second the number which checked exactly and the last the number which checked within 150 lbs.

TABLE 1.

	1	2	3
Fairbanks,	33	24	33
Howe,	12	6	12
Buffalo,	12	8	12
Carnegie,	12	10	12
Standard,	12	9	12

The first item shows data from three separate Fairbanks scales while the others are from one scale of each make. Records equally as good have been made by other scales but no definite figures were obtained.

In the earlier part of this division, the four figures shown gave the type of Fairbanks scale. It will be seen that the Sampson type can be built with the same overhang to the scale rails and gain the same advantages as the Fairbanks type.

OVERHANG.

The question of the scale having overhang is one to be considered.

Fig. 35 represents a scale with no overhang to the scale rail. It will be seen that when the wheel of the oncoming car "falls" across the opening between the scale rail and the track rail that the blow strikes the weigh bridge beyond any support, and that the full weight on the pair of wheels is precipitated upon the bearings of the first section in such manner as to give a leverage, increasing the load, perhaps, 12 per cent and also giving a tilting action to the weigh bridge which has a tendency to lift the bridge from the bearings of the second section, and has in some instances been thought to injure those bearings. This was until recently the universal manner of construction. To overcome the trouble named, and in the anticipation of relieving the end section of the wear and injury, shown by broken levers and dulled bearings, the designs following have been introduced:

Fig. 36 shows the design used by the P. R. R., B. & O., Southern and other roads. As used by them it places the opening between the scale rail and track rail directly over the first bearing. This brings the full shock of

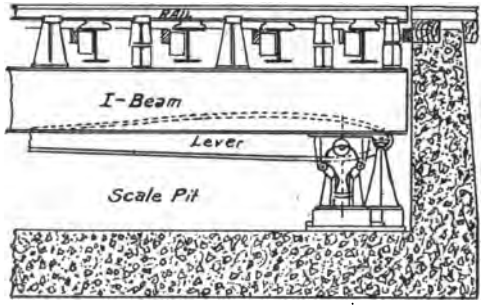


Fig. 35.– Showing no Overhang.

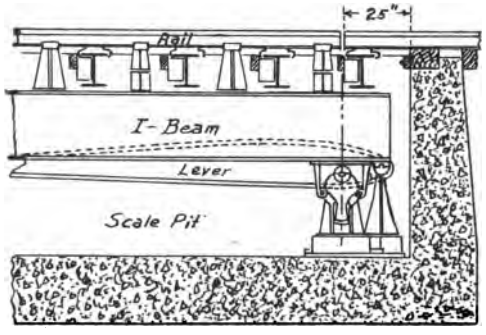


Fig. 36.– 25 in. Overhang. Opening over First Bearing.

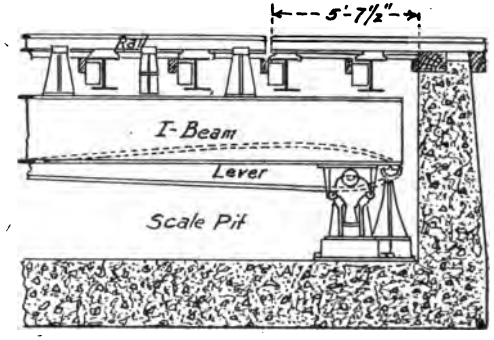


Fig. 37.– 5'-7½" Overhang. Opening ⅕ of the distance from end Bearing to next Bearing.

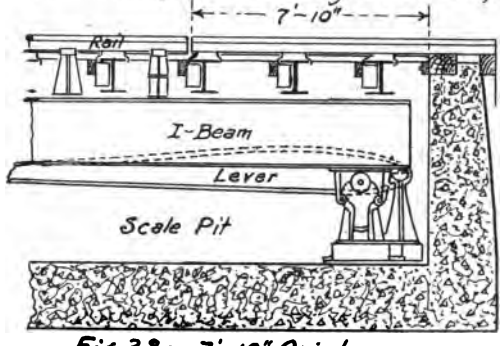


Fig. 38.– 7'-10" Overhang.

impact directly on the bearings of the first section. This is thought by some to be especially injurious as there is nothing to break the blow save such cushion as may be provided. It avoids the injuries caused by the supposed tendency of the weigh bridge to tilt in the plan, Fig. 35, but it brings the entire load of the wheels directly over the most sensitive part of the scale.

Fig. 37 shows the method adopted by the B. & L. E., Carnegie, and several other companies, and consists in increasing the overhang so that the opening between the scale rail and track rail will be at a point variously one-sixth, one-fifth and one-third of the distance between the first and second bearings of the weigh bridge. This, besides dividing the load between the two bearings, brings the shock where all possible slight deflection of the parts is utilized to modify the shock of the blow or impact before it reaches the knife edge of the section. This form of construction makes a long section and increases the cost of levers and weigh bridge.

Fig. 38 shows a form of construction which has been adopted in some instances where a six-section scale is used. It distributes the load equally between the two end sections as the load "drops" across the opening in the rails and has all the incidental advantages described in the last scale.

Fig. 39 shows two typical cars of the drop-bottom gondola type which are short and concentrate the load on the scale. These are much used and with the maximum load weigh 154,000 lbs. (44,000 lbs. for the car and 110,000 lbs. for the load.) This gives an axle load of 38,500 lbs.

Comparison of Scales.

Let us examine the action of this car on these different types of scales. If we assume in each instance a scale with scale rails 46 ft. long there will be a length over scale irons and distance between bearings about as follows:

Table 2.

	Length of scale irons	Length of section
Fig. 35,	46 ft.	14 ft. 2 in.
Fig. 36,	50 ft.	15 ft. 4 in.
Fig. 37,	57 ft.	17 ft. 8 in.
Fig. 38 (6 section)	61½ ft.	11 ft 6 in.

It will be readily admitted that the blow or impact as the car wheel "falls" across the opening between the rails puts an increased strain on the scale parts. It is customary to assume this to be equal to twice the load on the axle, for purposes of determining the strength needed by the scale parts. For the purpose of this paper we will assume the above. To determine the strain on the scale parts and the injurious effect of the blow on them we will also assume Fig 36 as 100 per cent in each case, and from this we obtain the figures in the table following. These are empirical, and it is possible to compute the blow and secure a somewhat different result. The injury is determined by results obtained from the use of sheet lead on a small number of scales.

Table 3.

	Force of blow per cent	Injury from blow per cent
Fig. 35,	112	117
Fig. 36,	100	100
Fig. 37,	80	72
Fig. 38,	50	33

Taking the loading as shown in Fig. 39, and assuming an axle load of 38,500 lbs. we deduce the loads on the four types of scales as shown in the next table. Column A gives the load on the first section when the first pair of wheels falls across the opening between the scale rail and track rail. Column B is the load on the first section (second section in Fig. 38) as the second pair of wheels of the same truck falls across the rail opening. Im-

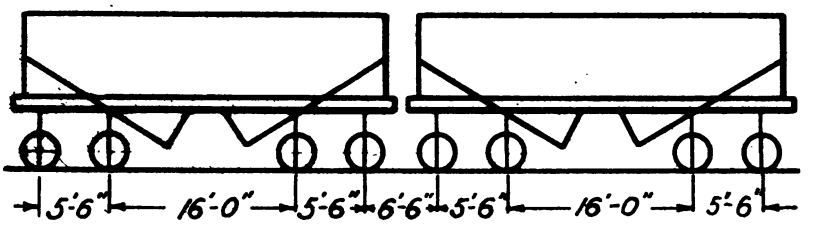


Fig. 39.—Showing Concentrated Loads on Track Scale.

pact of 100 per cent as above noted is added. Column C is the load on any intermediate section when two cars are being pushed across the scale coupled, and the scale section or bearing, as shown in Fig. 50, is directly beneath the center between the two cars. This is assumed to be the greatest load which can come on a section.

TABLE 4.

	A	B	C
Fig. 35,	86,000	117,500	89,500
Fig. 36,	77,000	102,000	94,000
Fig. 37,	62,000	81,000	103,000
Fig. 38,	38,500	76,000	74,000

It must be borne in mind that these figures will bear a different relation to each other if the length of the scale rail is changed. It is inserted merely to show that with a car such as is in every-day service on our roads carrying only its rated load that a load of from 40 to 60 tons is placed on some one of the sections of our track scale.

The question not unnaturally arises as to which will be the best policy; whether to design the knife edges, levers and parts for the imposed load of 60 tons, with the proper allowance for safety factor, and use Fig. 35; or to use the similar factor and an imposed load of 52 tons, using Figs. 36 or 37; or to use Fig. 38 and the load of forty tons. The argument of those favoring Fig. 35 usually ignores the greater destructive action of the impact on the knife edges over the other designs. Those favoring Fig. 36 usually deny that the action of impact is more destructive on their scale than on Fig. 37. With a view of shedding light on this subject a scale of each type in the figures given herewith was assumed. The weight of the various scale parts was calculated according to the rules given in the report of the weighing committee of the American Railway Association, as far as these went, and of good bridge practice for the balance. The rules of the committee for knife edges, etc., were used with Fig. 37 as a basis. Results as follows were secured:

(Actual weights are not given, nor lengths of bearings, as this is only for comparison.)

TABLE 4A.

	Weight of weigh bridge (per cent)	Weight of scale parts (per cent)	Length of bearing p'ts (per cent)
Fig. 35,	72	76	113
Fig. 36,	82	82	98
Fig. 37,	100	100	100
Fig. 38,	86	82	108

These deductions indicate that if scales of equal strength and probable wearing capacity are secured there should be no very large difference in costs of the four plans, except as the prices are affected by the overhead charge of the scale company. Opinions will differ as to how justifiable this charge may be. It will be high on a plan where the scale company has to make new patterns unless there be a large assured demand.

Fig. 38 implies a scale of six sections, and as the American Railway Association recommends four sections, and the replies to our queries (Appendix A) show a divergence of opinion, it has been thought worth while to inquire into the comparative accuracy of the four and five section scales. Two prominent roads which made reports to the committee have for their standard a scale made by the same manufacturer and of the same rated capacity. The following figures are taken from their reports to the Minnesota Railroad and Warehouse Commission:

TABLE 5.

	Road A	Road B
No. of scales in state,	23	34
No. of scales on bad foundation,	10	6
No. of standard scales,	13	28
No. sections in standard scales,	4	5
No. tests of standard scales,	33	41
No. of scales found correct,	14	24
No. of scales weighing too light,	14	16
No. of scales weighing too heavy,	5	1
Percentage of scales correct,	42	59
Percentage found too light,	42	39
Percentage found too heavy,	16	2

It is not contended that this shows one type to be superior to the other, but it does indicate that one type may be made to give service equally as good as the other.

KIND OF METAL.

In the present stage of the discussion as to the relative merits of cast iron and the various kinds of steel for scale parts, little of a positive nature can be stated. With our longer and heavier four section scales it is becoming more and more a problem as to the use of cast iron for levers. So long as they can be used there is this to be said: the point where deflection occurs and the point where the lever breaks is not wide, and the probability is that a weak lever will break soon after it deflects to an extent that would cause erroneous weight. This is not true of steel. Owing to the difficulties heretofore experienced in making steel castings, and the uncertain results secured, there is small enthusiasm for their extended use. Steel castings should not be confused with other steels called "cast steel," as they are entirely different, and are what their name indicates. Most scale men are in favor of using cast iron where it can be used. Some use is made of forgings for the transmission levers. The committee has not attempted to discuss or recommend the merits of the various metals but undoubtedly the use of steel will increase.

It appears to be a nearly uniform practice to use cast iron for supports. The use of steel in levers is largely confined to main levers in scales of 150 tons rated capacity and over.

Another strain to which the track scale is subjected is the longitudinal thrust resulting from a car being stopped on the scales or starting into motion to move off. The manner in which the car is stopped or started has much to do with the effect on the scales. When the engine has but one car between it and the car on the scale, the car is stopped and started gradually, with little or no shock. If there be six or more cars between the car being weighed and the engine the slack causes the car on the scales to be jerked to a stop and bumped into motion with much force. It has been suggested that this force be estimated as one fifth the weight of the car. In case of the car we have been considering this would be a thrust of 30,800 lbs. Referring back to the description of the different makes of scales, it will be seen how necessary is the device for absorbing this shock before it reaches the bearings. It will also be seen how essential it is that the device for preventing too great an oscillation should be of sufficient strength to accomplish its purpose. It

is also necessary, where check rods are used, to keep them level. A 24 in. check rod one inch out of level might bind enough to change the weight shown on the beam nearly 1,000 pounds.

KNIFE EDGES.

Knife edges or pivots are referred to in Appendix A. There is a special composite steel for this use, but the committee has been unable to find a manufacturer producing it in commercial quantities. It will probably soon be perfected and placed on the market. In the meantime the following description is the best which has been submitted to us:

"In order to produce a proper steel for scale pivots and knife edges it is most important to manufacture a steel which will possess the two essential features of the necessary degree of hardness combined with the maximum toughness; also, at the same time to have a steel which will distort or warp least in hardening, and with this idea in mind the Crucible Steel Company of America has been supplying what they term their 'special alloy scale pivot steel.'

"It is well known that as the carbon increases beyond .85, the brittleness increases likewise and the tendency to warp grows with the steel having .85 carbon as the lowest co-efficient of expansion; to this latter fact the tendency to warp least is due. The special alloy scale pivot stock possesses the hardness of a very much higher carbon steel; at the same time it possesses the physical features just mentioned of the lower carbon steel, i. e., one in the neighborhood of .85 or .90. To accomplish this chromium and manganese have been introduced in connection with cleansing and reducing agents, such as vanadium.

"The steel from which this stock is furnished is in a passive condition, that is, absolutely free from working strains and shows the best physical condition as is shown by the following physical properties:

Elastic limit, ... 65,000 to 75,000 lbs. per sq. in.
Tensile strength, ...100,000 to 110,000 lbs. per sq. in.
Elongation in two inches, ...20 to 25 per cent
Reduction in area, ...45 to 55 per cent

"When this steel is hardened the elastic limit is increased to about 185,000 lbs. per sq. in., and the tensile strength to about 220,000 lbs. per sq. in.

"The elongation and reduction of area are, of course, lowered very materially, but when the steel is drawn or tempered after hardening—say by heating it thoroughly in oil at 300 deg. F.—the elongation and reduction of area will be about as follows:

Elongation, ...4 per cent
Reduction, ...20 per cent

"The hardness of this steel in this condition, as determined by the Shore sclerescope, is .85 to .90.

"Any good coke, gas or electric furnace can be utilized as the means for heat-treating this stock, the essential feature being to have a furnace which will supply equal heat distribution, thus insuring these pivots and knife edges being uniformly heated. It is, of course, best to have such a furnace equipped with a pyrometer attachment to enable the hardener to secure uniform heating of the knives and pivots. The rod adjustment of the pyrometer should be located in the furnace so as to register the true temperature of the same. An oil tank of 100 to 150 gallons capacity, surrounded with a circulating water jacket is preferable for chilling. We find the best oil for chilling to be a good thin material oil (petroleum) with a flash point of 375 to 400, the circulating water jacket being utilized to keep down the temperature of the chilling medium.

"When forging, heat to 1,750 to 1,800 deg. F. When the steel has dropped to 1,450 or 1,500 deg. F., and further forging is found necessary, it should be put back in the furnace and brought up to 1,750 or 1,800 deg. F. again.

"In forging steel there is more or less scale raised on the surface and

care should be exercised to throw this scale off rather than to pound it in. If this is done, it will leave the surface of the steel in good clean condition for hardening."

Weigh Bridge.

The weigh bridge of a track scale is of equal importance to the scale mechanism if the scale is to do accurate work and render lasting service. It can be safely said that no scale can continuously do accurate work unless it be supplied with a weigh bridge sufficiently substantial and heavy to prevent the transmission of vibration to the scale mechanism. The weigh bridge is a girder, and should be designed by a competent bridge engineer familiar with the use it is to receive and service it must perform.

Fig. 40.—Weigh Bridge for Pennsylvania Railroad Track Scale

Fig. 40 shows a weigh bridge about 56 ft. long of one of the track scales of the Pennsylvania R. R. just before being lowered into the scale pit.

Fig. 41 shows the same weigh bridge after being lowered into its place in the pit. This also shows the check rods in place as well as the longitudinal levers and scale beam. This is one of the heaviest weigh bridges in the country. It embodies the best practice in such work. This is a four section scale with a span between bearings of about 17½ ft.

In the newest installation of a very heavy four section scale, on the Norfolk & Western, a different type of scale bridge is used as shown in Fig. 42. It is called the Wentworth girder (after the assistant chief engineer of that road).

This illustrates the advantage claimed of this form of girder for a weigh bridge. It is argued that there is always an upward deflection to the continuous weigh bridge, as illustrated in the upper section of Fig. 42. The lower section shows the Wentworth girder. The faith of the N. & W. Ry. is shown by the fact that they are using these on twenty new installations of heavy scales.

There is a feeling among scale inspectors that these weigh bridges, even when well set, and made to first class specifications, will be affected by changes of temperature and that the continuous girder in a weigh bridge is not always in such shape as to give an even distribution of the load to all bearings.

Fig. 41.—Scales and Weigh Bridge in Place, P. R. R.

Having thus touched briefly upon the different points in scale design which affect our part of the work we will describe a few typical scale installations.

Typical Installations of Track Scales.

Fig. 43 shows the Pittsburgh and Lake Erie track scale. The dimensions are given on the drawing and the plan can be readily understood. The main features of this scale are: The load is brought on the scale without any blow effect, and applied gradually. Its application is midway between the end knife edges, and those of the first section from them. The scales are made of extremely stiff and strong material, and the knife edges are about twice the length of those ordinarily used. The deck of the pit is supported on the side walls and is covered with iron plate, making it a waterproof scale covering. The scale pit is large enough to permit a man to walk about in it erect, and access can be had through a trap door in the office, so that the operation of the scale can be tested at all times. (For the description and Fig. 43 we are indebted to the Railway Review.)

Fig. 44 shows a sketch of the Bessemer and Lake Erie scale, built by the Carnegie Steel Co. Its main features are the overhang to the track rails, bringing the impact of the car entering the scale on the weigh bridge at a point one fifth the distance between the end knife edges and those of the

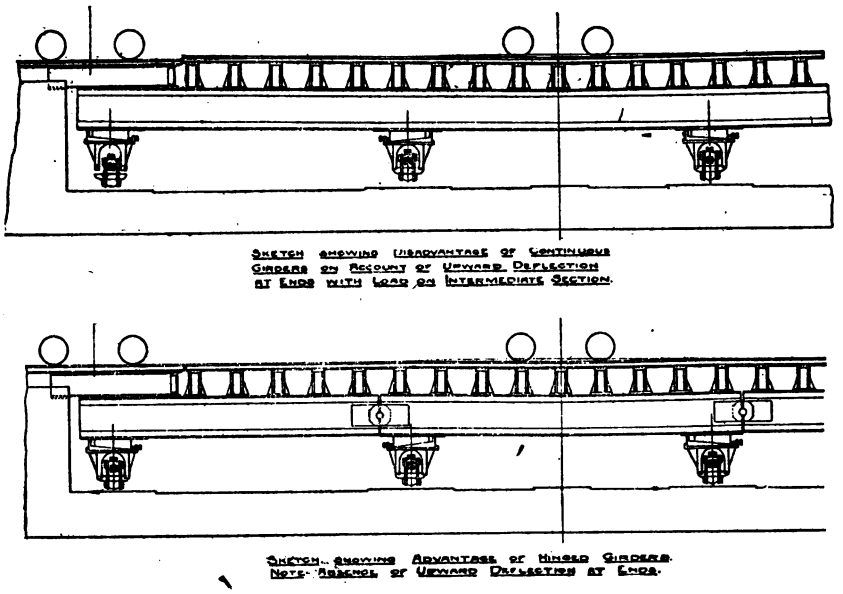

Sketch showing Disadvantage of Continuous Girders on Account of Upward Deflection at Ends with Load on Intermediate Section.
Sketch showing Advantage of Hinged Girders.
Note: Absence of Upward Deflection at Ends.

Fig. 42.—Sketches Showing Advantage in Favor of Hinged Girders for the Weigh Bridge.

first section next to them. The deck is supported the same as the preceding. but is not of iron, although some are iron sheathed. This scale is noted because of steel being used to a greater extent in its construction than in any other scale. Another item of importance is that all knife edges, pivots and bearing plates are removable. The scale pit while not quite as roomy as the one before described is of such size that a man can walk around and inspect all parts of it.

Fig. 45 is a scale recently installed on the Southern Railway. This scale illustrates the type having the shortest overhang to the track rails, being only about two feet, which brings the impact or blow effect directly over the end knife edge. This scale has a deep pit, rigid deck and other features similar to the preceding. A notable feature is the dispensing with check rods.

Fig. 46 shows the older form of installation, and is the plan heretofore used on the Illinois Central. This is one of the best plans and installations of the last decade. It has not the deep pit and rigid deck, but it is a type which has done good service where an efficient scale department was maintained who had authority to enforce the necessary weighing and maintenance rules.

Fig. 47 is a recent installation of the Sampson type on the Chicago and Alton. This is a thoroughly modern scale of the type shown in Fig. 17. No especially noteworthy features are embodied and the drawing tells about all there is to it.

As a special scale we illustrate in Fig. 48 the ore scale of the Duluth and Iron Range R. R. This scale weighs the short but heavy ore cars with their concentrated loads. It has no dead rail, the engines passing over the scale under steam. Weighing is done in motion, the cars being weighed in train, coupled and drawn by an engine, the weights being taken by a Streeter-Amet recorder. The results secured are very satisfactory, giving weights entirely within permissible limits. The length of the scale is fixed by the length of the ore cars, which is 24 ft. over couplers.

Another special scale used to a considerable extent in the southwest is

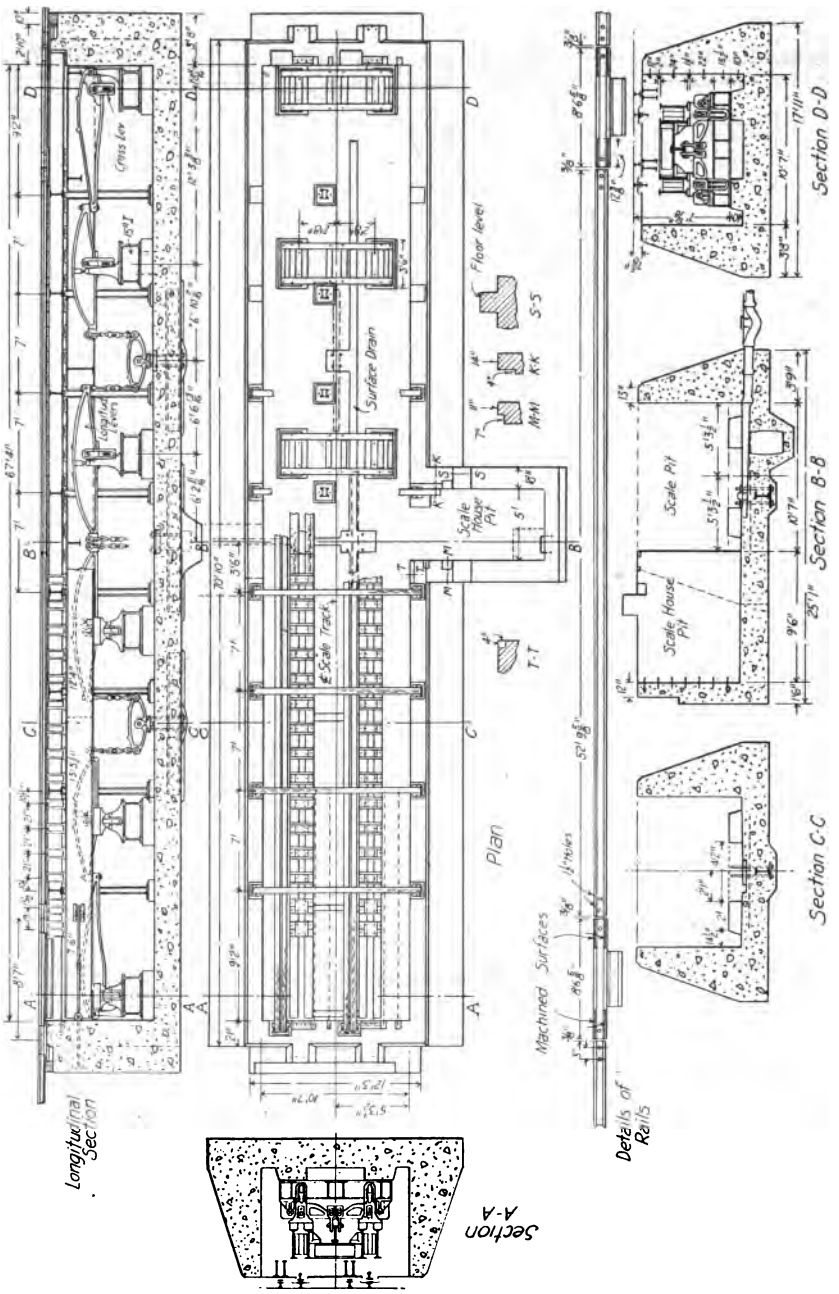


Fig. 43.—Pittsburgh & Lake Erie R. R. Track Scale.

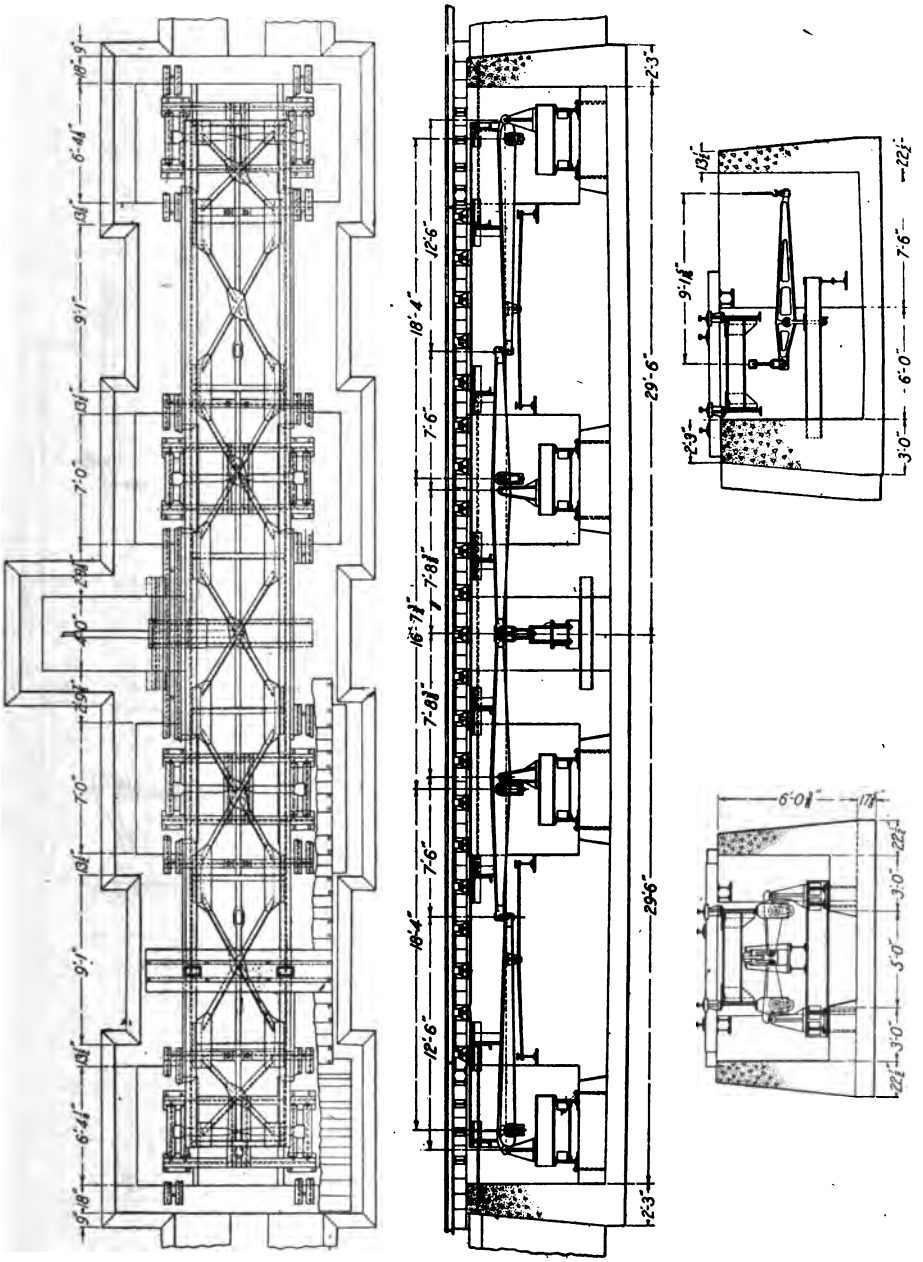


Fig. 44.—Bessemer & Lake Erie Track Scale.

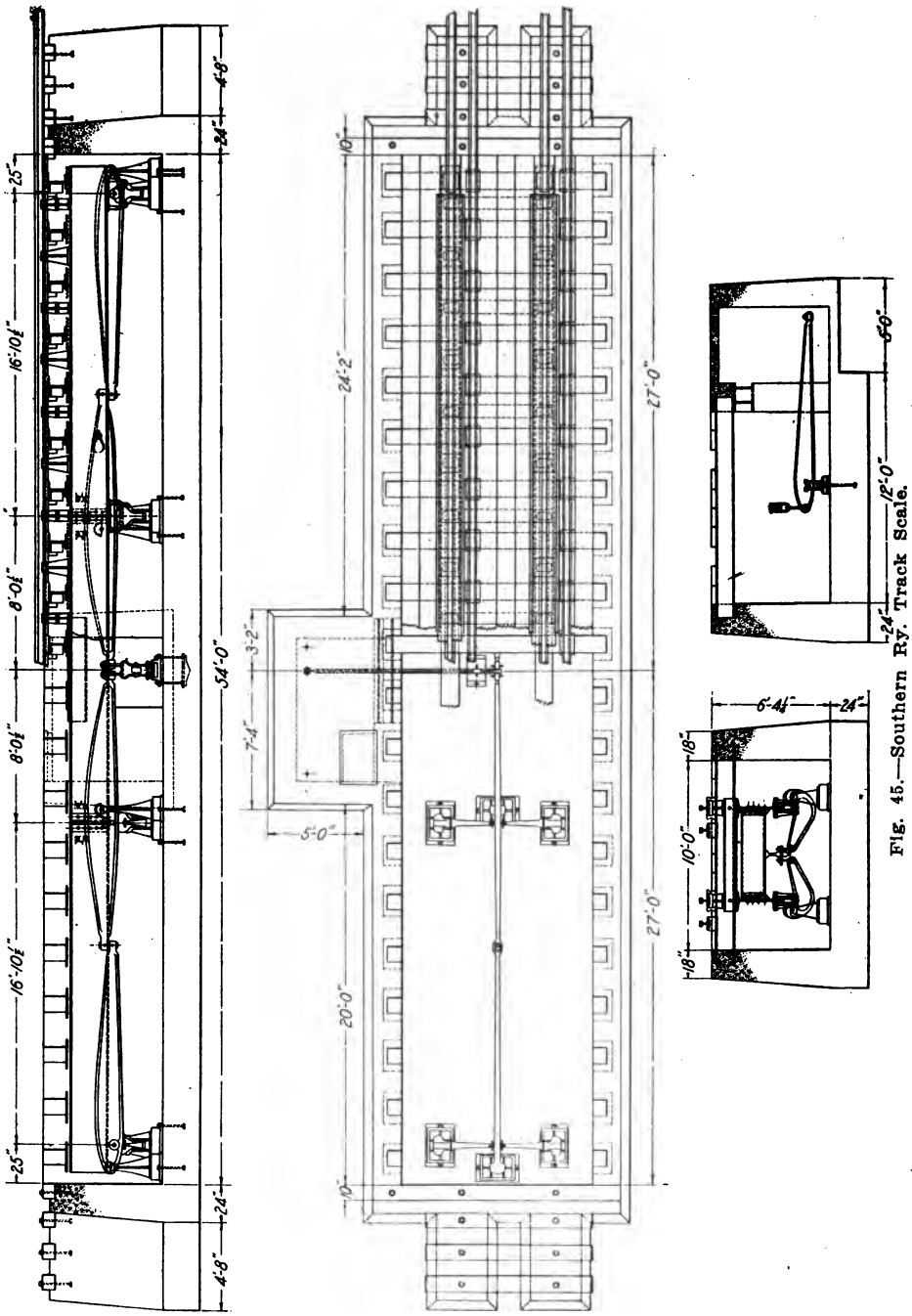


Fig. 45.—Southern Ry. Track Scale.

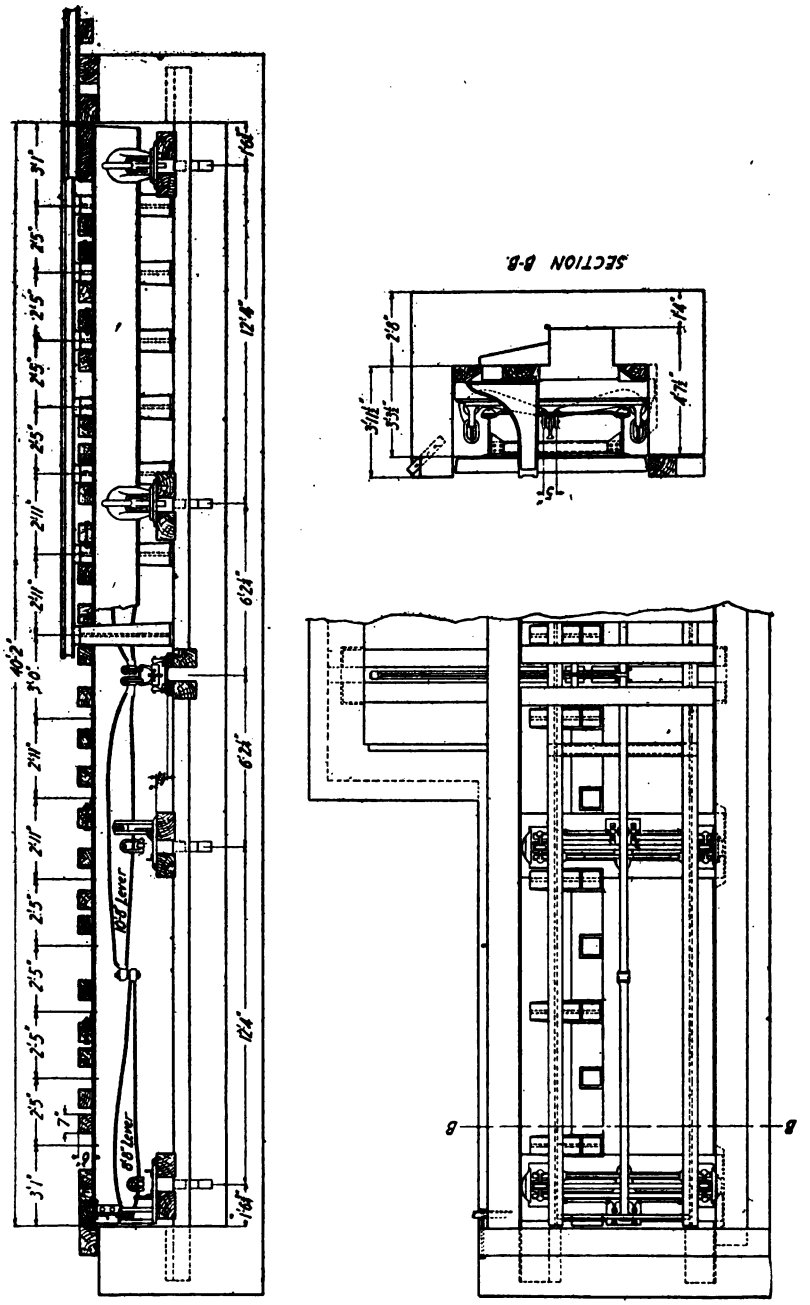


Fig. 46.—Standard 40-Ft., 100-Ton Track Scale, Illinois Central R. R.

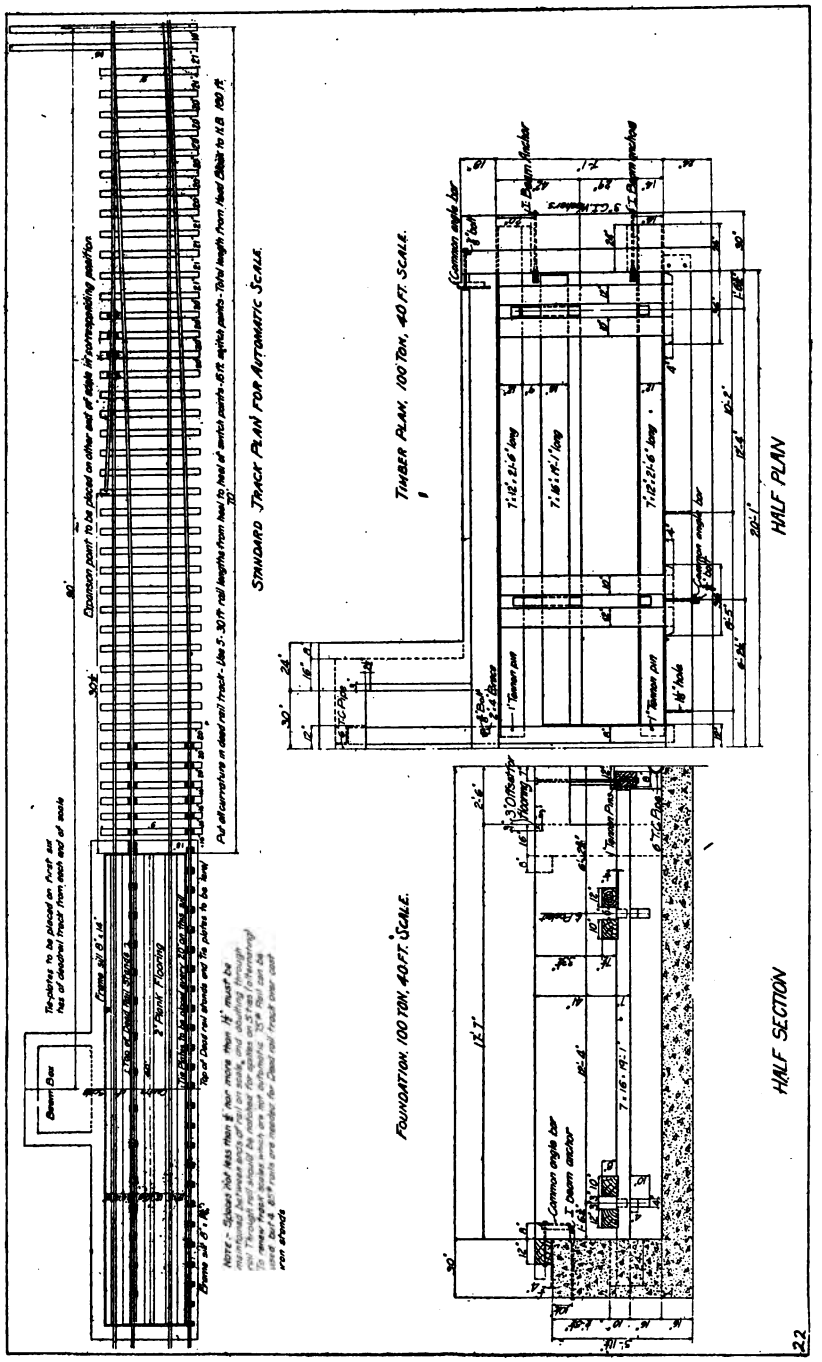

STANDARD TRACK PLAN FOR AUTOMATIC SCALE.
TIMBER PLAN, 100 TON, 40 FT. SCALE.
FOUNDATION, 100 TON, 40 FT. SCALE.
HALF PLAN
HALF SECTION
22

Fig. 46.—Standard Track Scales, Illinois Central R. R.

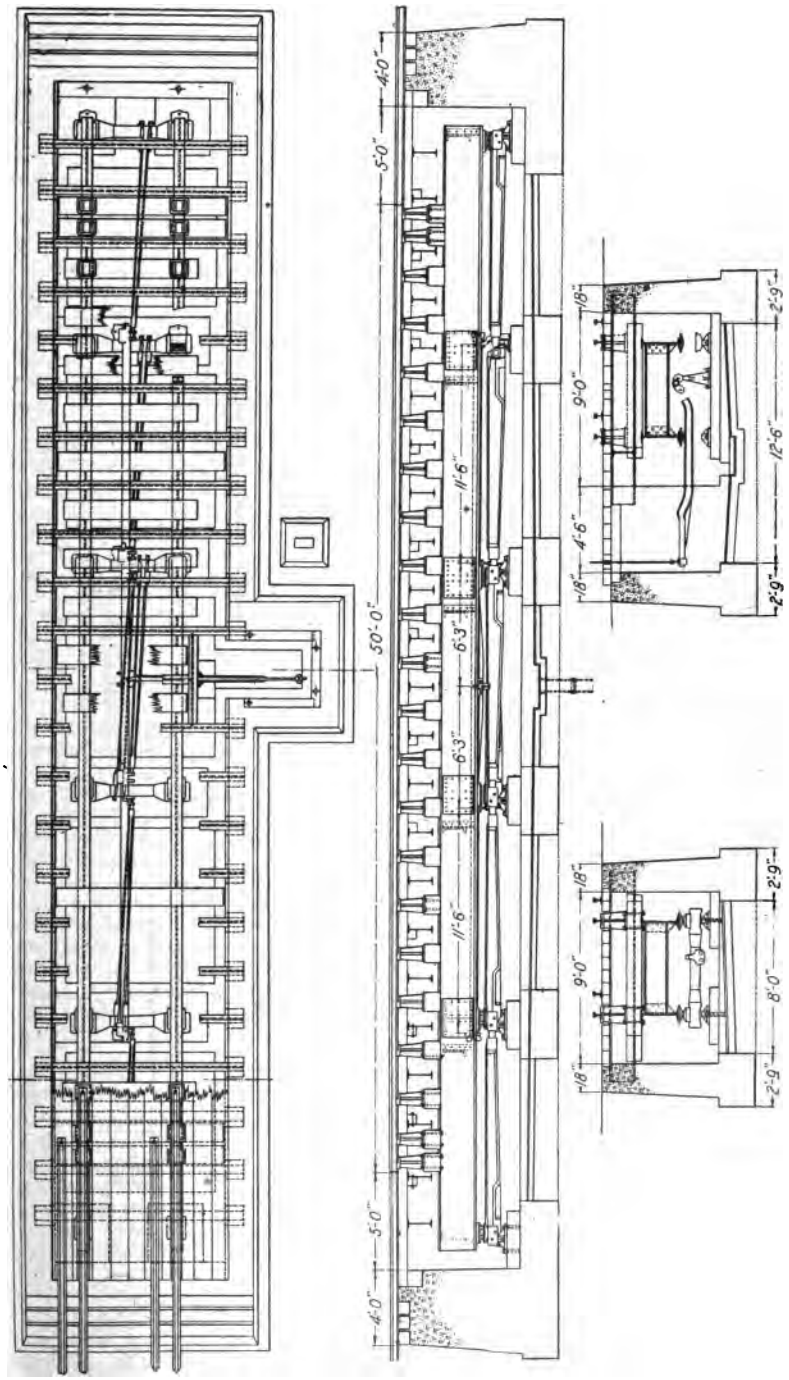


Fig. 47.—Chicago & Alton Track Scale.

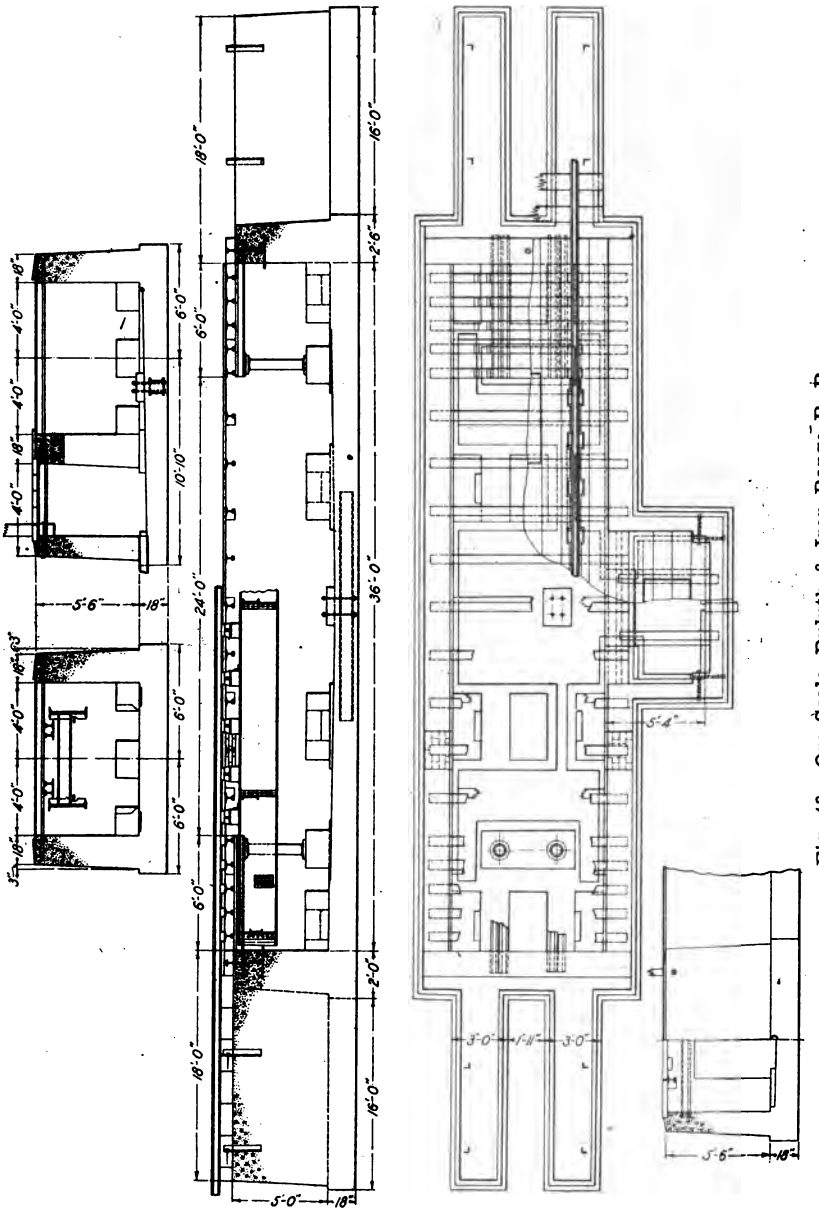


Fig. 48.—Ore Scale, Duluth & Iron Range R. R.

shown in Fig. 49. This scale is used at coal mines in the following manner:

The coal car is dropped by gravity on the upper end of the scale and weighed light. It then moves slowly along under the chute, being filled with coal in its passage. As it nears the end of the scale and is filled, or loaded, its weight is again taken, giving both the light weight and loaded weight at the same weighing. This scale is the type used on the El Paso & Southwestern Ry., and the practice above described gives uniform satisfaction.

LENGTH.

The question of the length of the track scale is one of importance, and one for which hard and fast rules can not be made. One road will have a traffic which is almost wholly confined to cars 36 ft. in length and with a wheel base four or five feet less. Another has few cars less in length than the newer box car, the standard for which seems to be 40 ft. in clear inside length, and which is from 8 to 14 ins. longer outside and has a wheel base of 36 ft. This road has in addition quite a traffic in furniture, automobiles, hay, etc., using cars as long as 50 ft., with a wheel base approaching 46 ft. Coal cars vary in different sections from 34 to 41 ft. feet inside, the wheel base being four or five feet less. When a road at a certain station has a traffic almost wholly carried in cars of not over 36 ft. wheel base, and not one car a month with a wheel base of over 38 ft., it is a question as to how far they are justified in lengthening their scales to accommodate cars of this length.

The recommendation of the American Railway Association is that the scale be long enough to weigh the cars offered, and preferably longer. It is not likely that the average car will grow shorter. It is possible that at some of these stations the small amount of freight using these cars can be arranged for at an agreed estimated weight. Hay is known to weigh an approximate amount per bale, and the bales might be counted. The probabilities are that the next five years will see a great change in the scale question.

The answers, as summarized in Appendix A, to the queries sent out show a diversity of lengths of scales, 40 ft. being the shortest length recommended and 67 ft. the longest. The latter is for gravity weighing.

Another question which will affect the length of the scale is the plan of installation adopted. If a scale is installed as shown in Fig. 35, the scale iron length will give a greater scale rail length than in any other design. Some scale companies claim that one loses by using the overhang to the track rail; that the scale shown in Fig. 37 will give a scale rail length of 46 ft. when so installed, and that the same scale installed as in Fig. 36 will give an effective scale rail length of 53 ft., whereas, if installed as in Fig. 35 it will give an effective length of 57 ft. Some purchasers have gained the opinion that the results would be the same in 36 and 37, and that if an easer rail were added to the scale they would gain the same end with Fig. 35. Tables 3 and 4 will dispel this idea. This question should receive the most careful consideration and study. The cost should not stand in the way of securing the greatest accuracy in measuring the weight.

The capacity of the scale is a matter over which there is a large amount of confusion. The scale companies give their scale an alleged capacity of 100 tons, 150 tons or 200 tons. The average buyer supposes this to mean that it is calculated to weigh correctly and without undue wear or injury to the scale, a load in the usual car up to that amount. It is not clear as to how the scale companies arrive at their rating. The Standard Scale Co. has put out what they call a "Model Scale Specification." In this they say the capacity of the scale is 150 tons, and each section is assumed to bear one fourth this amount. One fourth of 300,000 lbs. is 75,000 lbs. By Table 4 it will be seen that the load imposed on the sections of a 46-ft. 4-section scale is over 100,000 lbs. for a car load which weighs little over half the rated capacity of this scale. This is not meant to condemn the scale or method, but to point out how misleading it is. Fig. 50 shows cars in position on the scale (in this case a 52 ft. scale), where the weights shown in column C in Table 4 are obtained. This is a position obtaining on all scales where spot weighing is

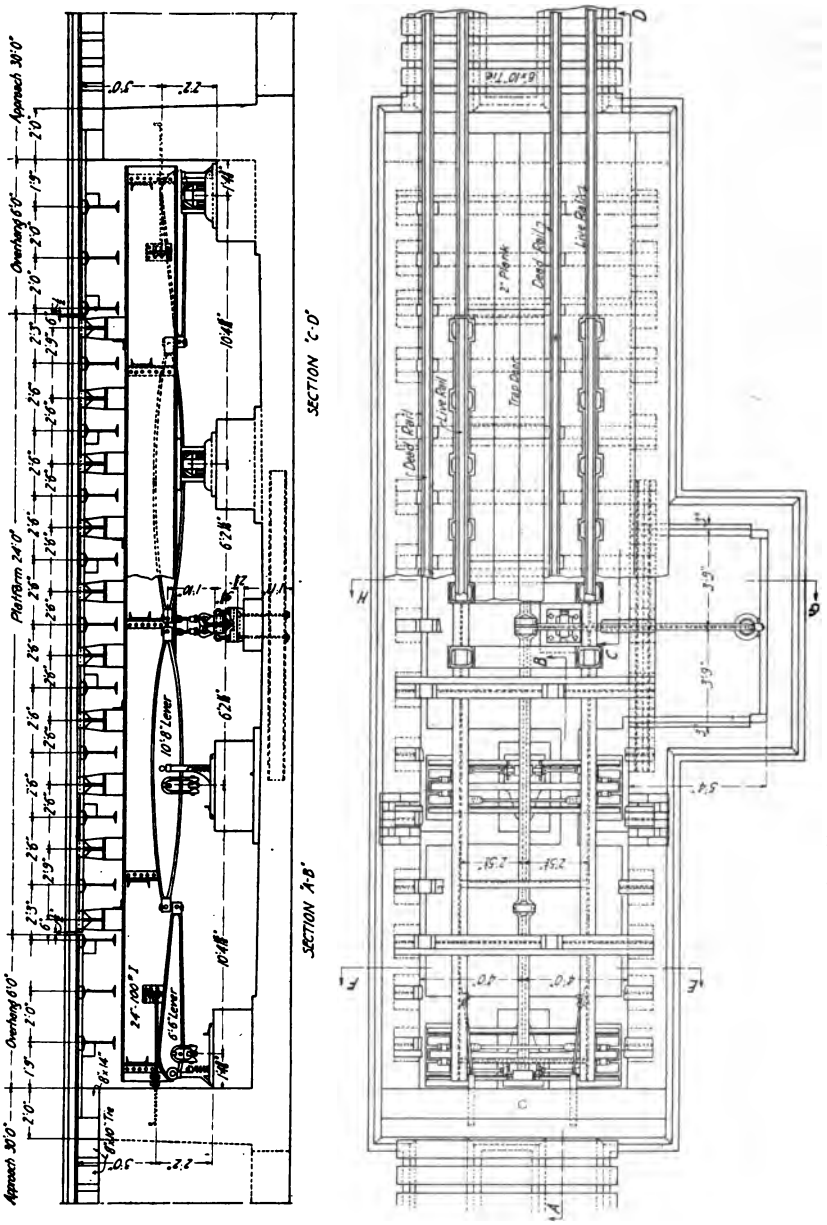
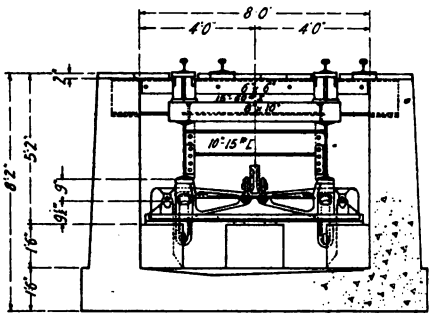
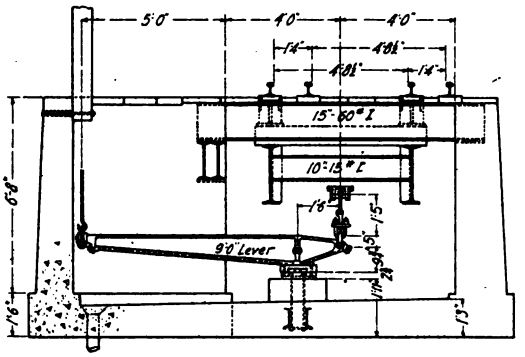


Fig. 49.—Gravity Scale, El Paso & Southwestern R. R.



SECTION "E-F"



SECTION "G-H"

Fig. 49.—Cross Sections of E. P. & S. W. Scale.

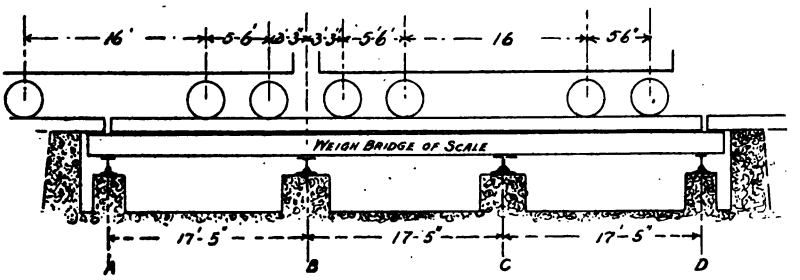


Fig. 50.—Concentrated Weight on One Bearing.

done. In a letter to the committee Mr. A. Bousfield, chief engineer of E. & T. Fairbanks & Co., gives the following information:

"You will notice that the stresses in the B. & O. scale are figured for a distributed load of 330,000 lbs., while the stresses in the Santa Fe scale are figured for a distributed load of 220,000 lbs."

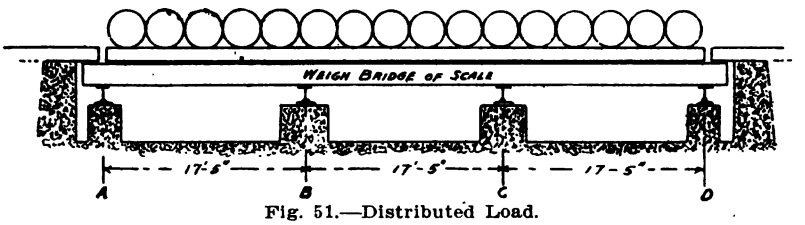


Fig. 51.—Distributed Load.

Fig. 51 shows a 52 ft. scale with a distributed load. It will be seen that the two intermediate sections each receive one third of the load and the two end sections each receive one sixth. This is not quite true of the Santa Fe scale, shown in Fig. 35, as the end section through the scale bridge extending beyond the end bearing carries slightly more than this proportion. The Santa Fe scale with its sections each computed for a load of 73,333 lbs. (it being assumed that 100 per cent is added to the end section to cover impact), receives the loads shown for Fig. 35 in table 4. Thus the end section with the car shown receives a load of 117,500 lbs., and the intermediate sections a load of 89,500 lbs. This does not mean to assume that the scale is unsafe. There is a safety factor used, and the members are supposed to be proportioned for a 50 per cent greater load than the rated capacity. It does however indicate how closely the scale is loaded to that point with a car weighing but three fourths of its rated capacity. The B. & O. scale is, by the above, calculated for a load of 110,000 lbs. on the intermediate sections, and with impact the same on the end sections. By table 4, Fig. 36, altered to suit the longer scale of this plan, 52 ft. as against 46 ft. in the table, we find the load on this scale, as in column B of that table, to be 103,500 lbs., and as in column C of that table 101,000 lbs. The above indicates how little the rating indicates the real service capacity of the scale.

It is hoped that the American Railway Engineering Association may take up this question, and that a committee of this association may work with them in this matter and also in formulating a glossary of scale terms. As it now is there is but little uniformity in custom of names for parts of scales.

Scale Track.

This is the commonly accepted name for the track on which the scales are placed. It seems the accepted practice of our correspondents to place the scales, wherever it is possible to do so, on a track over which no switching is done. It also seems the general recommendation to place the scales on a track only long enough for the purpose of weighing. This is a matter which varies widely. In a yard where but one switching engine will be used no embarrassment will come from blocking the lead track with the train and engine while weighing is being done. Where two or more switching engines work at the same time, it is desirable that the scale track be of such length as to hold a full cut of cars at both ends of the scales. The extreme length of such a track reported to us is by the Duluth and Iron Range, where the scale track above the scale is long enough to hold three full trains, and below to hold one full train. This is necessary, as in the busy season two or three ore trains arrive closely following each other and it is necessary to keep the main track clear while weighing is being done.

The minimum length of a scale track is such as will give a tangent each side of the scales equal to the length of the longest car in service which will

be weighed. This distance should be on the same gradient as the scales themselves, and preferably level.

Pocket Track.

This is a name given to a short track leading to and across the scale, and used for no other purpose than weighing. It may be either stub or double end. Where it is used a scale without a dead rail is installed. Using a pocket track and locking the switches to it with Yale locks has proved a very successful way of keeping engines off the scales. The disadvantage of this plan is that it requires more track and space than the dead rail method, and the advantage is its greater safety from being used by engines and the fact that it dispenses with the dead rail and permits making the pit one and one half feet narrower. The deck of the scale, if of a rigid type, can be made very much lighter, as it carries little in addition to its own weight.

Dead Rails.

Are dead rails necessary? This is a question of growing importance as the railroads install better scales. With the old type of scales as shown in Fig. 21 it was considered almost suicidal to permit engines to cross on the live rail. Thirty or forty years ago the variation between wheel loads of engines and wheel loads of cars was much greater than at the present time. In 1875 the average freight car weighed 8 to 10 tons, had a rated capacity of 10 tons and could be loaded up to 11 tons. This made the maximum load 20 tons, of which 20,000 lbs. was borne by each truck and gave a load of 5,000 lbs. to each wheel. At the present time, coal cars weigh as high as 150,000 lbs., including the car, which will give a load of 75,000 lbs. to each truck and of 18,750 lbs. to each wheel.

Track scales, in common with rail, bridges and other railroad structures did not at first keep pace with the increased loadings. Ten years ago the knife edge was about the same as when the wheel load was one-fourth of what it is now. Since then, however, designers of track scales have provided for the new conditions. In 1875 the wheel load of the engine was more than double the wheel load of the cars while today the wheel load of the engines that operate over track scales does not exceed 24,500 lbs., or approximately 25 per cent more than the wheel load of the heaviest cars being weighed. The modern track scale is designed to take care of modern loads and for that reason a locomotive in passing over it is less harmful than it was when the scale was designed to weigh only the lighter loads.

Regarding the running of engines over the live rail of the scales, the following from our member, J. W. Fletcher, Jr., of the Carolina & Northwestern is to the point:

"We do not think it hurts a scale of the type we use to allow the engines to run over it. Our scales have 12 in. x 18 in. beams on which the floor rests, with the rails on the top of this. After eight years this timber has commenced to crush, and we are arranging to substitute steel I-beams, using an 18 in. I-beam in place of the 12 in. x 18 in. timber. We have two 150-ton Shay engines on the north end of our line where the timber and tannic acid traffic is heavy, and the gradients run from 105 to 170 ft. to the mile. These scales are without dead rails and the engines switch across them daily. So far I have been unable to see any wear on the bearings, and the scales are apparently in as good condition as when we put them in eight years ago, with the exception of the soft timber spoken of above. Having had this experience, with scales without dead rails, I have become a believer in them, because they can be installed in a minimum space, at less expense and cars can be weighed more quickly. There is also less liability for derailments."

The scales of most of the roads handling iron ore in the Lake Superior district are built without dead rails and the engines run over the scales in weighing. The speed is slow and the draw bar pull kept very light and even. It is noteworthy that the scales of the Duluth & Iron Range, and those of the

Duluth, Missabe & Northern, where this practice is the rule, were among the best ranking scales as to condition which the state inspectors found in the state. Some of the comments in answer to the question as to whether it is injurious to a scale to allow engines to run over the scale rail were: B. & O.,—" Depends on the capacity of the scale." B. & L. E.,—" Yes, when hauling a load." C., B. & Q.,—" Yes, if the weight of the engine exceeds the capacity of the scale." C., M. & St. P.,—" It depends on size of scale bearings or capacity of scale and weight of engine." P. R. R.,—" It does not do the scales any good." Vandalia,—" It helps to wear it out."

The committee is of the opinion that allowing engines to run over the live rail of a scale puts an undue strain on a scale, tends to excessive wear on the pivots, and shortens the useful life of the scale. This practice should be limited, or if possible, prevented.

On this subject Mr. T. B. Turnbull of the Ann Arbor writes:

" I believe that dead rails should be kept out of scales so far as possible, especially in colder climates, where the dead rail takes up a great deal of room and is continually giving trouble on account of filling with snow and ice."

With scales using ball bearings or rollers to absorb the shock or having one of the newer type of suspended bearings and an adequate length of knife edge, the injury from engines crossing the scale is greatly reduced. It must be understood that this presupposes that the scales are calculated to support the concentrated load, and not rated by the misleading method of using a uniformly distributed load as the weight of a locomotive is not evenly distributed.

Scale House.

In answer to our letters of inquiry we find that 56 roads advise the use of scale houses, while 24 do not. The question of locality does not seem to be the governing factor. The matter of space seems to be an important item. Where there is little room the space needed for the scale house often makes it impossible to have one. For safety, the center of adjacent tracks should not be closer than nine feet from the nearest part of the scale house.

Where a Streeter-Amet recorder is used, a house is necessary, and in a cold region the house must be heated in cold weather.

This is a question which roads must settle for themselves. It seems that where the weighing is done by some clerk from the freight house and does not require more than an hour or so per day, and is done in one or two cuts, that the house may be dispensed with. This conviction is heightened by seeing numerous scale houses left open and uncared for, and where the windows were left open in the coldest weather in order to enable the weighman to see better than he could through the unwashed windows.

Where weighing is continuous through any considerable part of the day a scale house is necessary. Where weighing is done in two or more intervals during the day and exceeding an hour at a time, a scale house is advisable. In some places for such work a canopy is used for sheltering the weighman from sun and storm. This is more airy than a house in hot weather and does not call for artificial light.

Lighting.

Sufficient light should be provided at all scale houses to enable the weighman to see the initials and number of the car, and to read the beam. These lights should be so located as to make impossible the casting of shadows on a car or beam by the men handling the cars. Some of the pictures of scale houses shown illustrate this point. The light should reach every part of the beam.

Easer Rails and Detector Bars.

In weighing cars in motion these two inventions of Mr. A. R. Raymer, assistant chief engineer of the Pittsburgh and Lake Erie, are two of the greatest aids to accurate weighing which have been brought out, and are almost indispensable. The easer rail is sometimes called a flexible rail, to distin-

guish it from another type of easer rail which has been used by some roads.

Figure 52 is a side view of the easer rail. As will be seen the rail is fastened to two angle bars of peculiar construction by two bolts, and the angle bar is attached to the scale rail and the track rail by a single bolt which is surrounded by a piece of pipe to ensure free action. This is also shown in Fig. 53 which gives an end or sectional view. Fig. 54 is another end or sec-

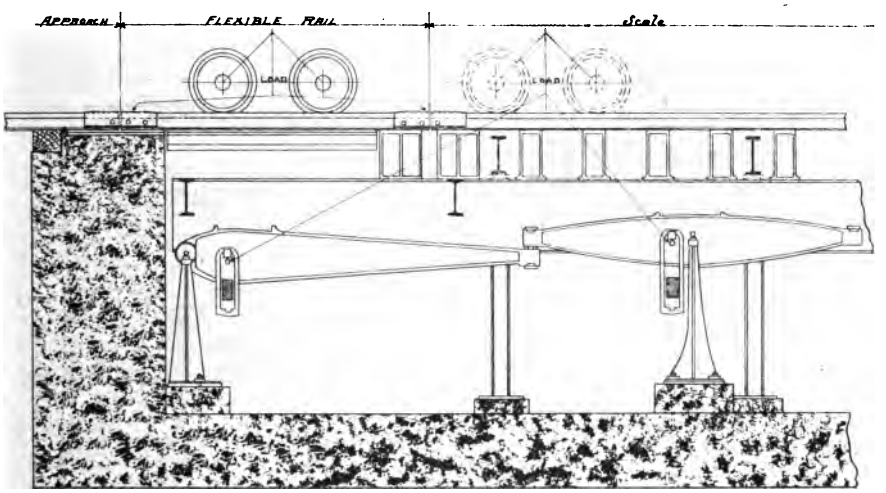


Fig. 52.—Easer Rail, Pittsburg & Lake Erie R. R.

tional view which shows the construction of the rail and its reinforcement, and also the rain shield which is a feature of the P. & L. E. installation. As will be noted, as soon as the first wheel crosses from the approach rail to the easer rail, it places some weight on the scale parts, which is gradually increased until the total weight of the car is on the scale. Mr. Raymer describes its action tersely by saying that it makes the difference between running directly on the scale equal to the difference between throwing rock on the scale and pouring sand on it. In this scale the easer rail is 8 ft. 7 in. long.

The detector bar is the same length as the easer rail, and is shown in Fig. 53. It is connected with the weighing mechanism in such a way that while a car wheel is against it, the recording machine cannot work. This makes it impossible to do weighing with a car following too closely or with one not yet off the scales. It prevents all arguments between switch crews and weighmen. Unless cars are run over the scales properly weights are not recorded.

Figure 55 shows a type of easer rail at one time in use on the B. & O. and other roads. The engraving is from the Railway Age Gazette, from which we take the following description:

"In order further to relieve impact on the scale, a buffer, or transfer rail, made of manganese steel is used to transfer the load from the approach to the scale rail. This is bolted to the approach rail and the box beams, and carries the outside tread of the car wheel. The buffer is in no way connected with the scale, plenty of clearance having been provided by cutting it out underneath and planing off the outside head of the scale rail."

A similar type of rail is used by the Frisco System, and perhaps by other roads. On the B. & O. scale at 39th St., Pittsburgh, last February the buffer

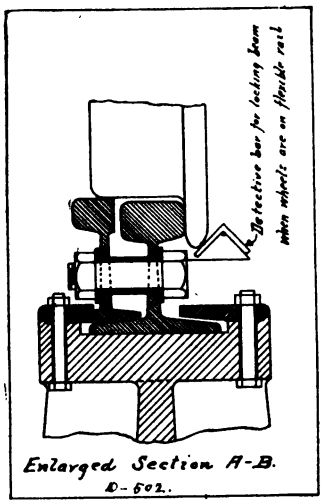


Fig. 53.—Easer Rail and Detector Bar, P. & L. E. R. R.

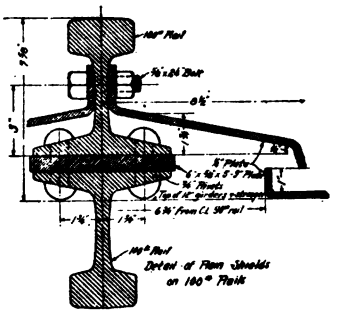


Fig. 54.—Easer Rail, P. & L. E. R. R., Showing Reinforcing and Rain Shield.

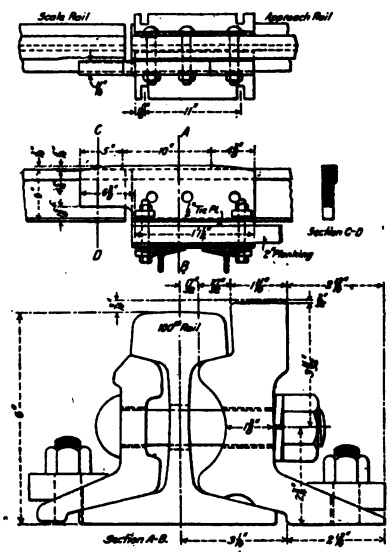


Fig. 55.—Easer Rail.

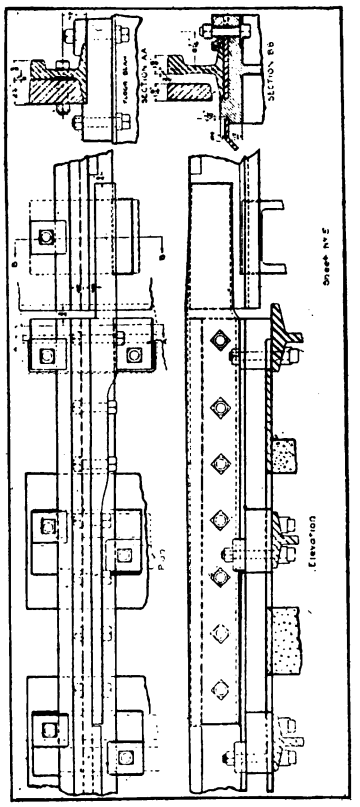


Fig. 56.—Bohannan-Dugger Easer Rail.

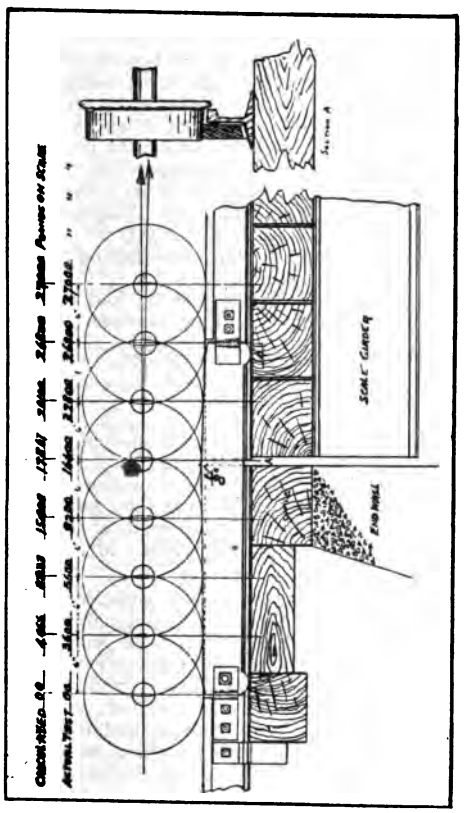


Fig. 57.—Bohannan-Dugger Easer Rail.

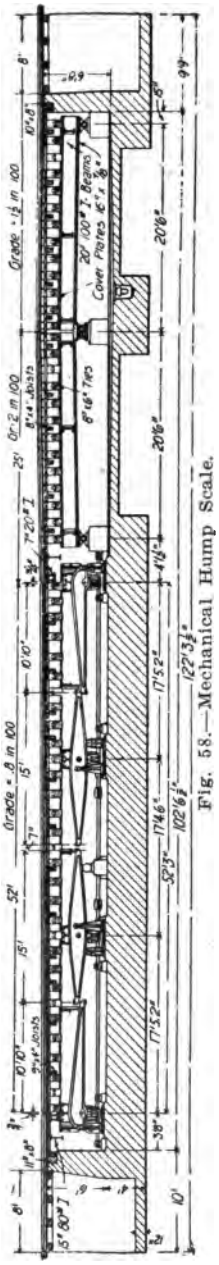


Fig. 58.—Mechanical Hump Scale.

rail had been removed. It would seem possible that this type might fail to alleviate the shock, as some wheels are rail-worn to an extent that would make them ride the buffer and drop with a shock at its end.

Bohannan and Dugger, of Ensley, Ala., have two types of easer rail, one similar to the B. & O. and the other having some similarity to the type of the P. & L. E.

The first named is shown in Fig. 56. This plan provides for cutting away of the head of the rail as shown in A A and B B, the latter also showing the clearance between the scale rail and easer, while the first named is firmly attached to the approach rail. The plan and elevation of the appliance is so clear that we omit further description. Both of these are made of manganese steel.

The other easer is shown in Fig. 57. As will be seen this uses the principle of the P. & L. E. rail. It rests by means of a lug at the bottom of each end of the easer on the flange of the approach and scale rails, being held to the former by a special angle bar and one bolt, and to the latter by an angle bar alone. This engraving also shows the principle on which it works. The weight which a loaded car places on the scale at each six inches of its travel across the rail was figured and the amount is shown in the upper line. A car was run on the easer and stopped at each six inch mark of its travel and weighed, and the results are given in the lower line. This cut illustrates Mr. Raymer's figure of sand and rock. Without this easer the 27,000 lbs. would have been precipitated on the scale at once, and the impact in falling across the opening between the rails been more harmful.

Mr. Bohannan informed the committee last March that he had patents on the first named device and had an application pending for one on the second.

Track Scales on Switching Humps.

A hump is usually an artificial elevation up which cars are pushed, allowing them to run down the farther side by gravity, usually to the track they are destined for. In many instances scales are placed a short distance below the apex of the hump, and the cars weighed as one by one they pass over the scale. It takes less time to weigh in this manner than by spotting or stopping each car on the scales; it is also less harmful to the scales. Mr. Romig writes of this:

"Humps and grades of scales have been experimented with for quite a number of years. We find that many engineers of maintenance, and mechanical engineers disagree very materially as to what has been proven. It has been found that the apex of the hump should not be a greater distance than 24 or 26 ft. from the end of the scale platform. The hump grade should be 2.1 per cent, varying slightly in winter and summer weather, and the grade of the scale platform not less than 0.6 of one per cent and not over 0.8 of one per cent. Scale platforms should have a grade on them, as a level platform with a grade above would make cars act very much the same as a boy sliding down hill on a sled and striking a level spot. It sets the cars to jumping. A number of tests have been made along this line. Variations in a 50-ton hopper car loaded with coal have run as high as 1,200 lbs. This arrangement of hump and grade allows cars of all lengths and descriptions to remain on the scale platform of 52 ft. in length about three seconds, and also insures uniform speeds so that automatic weighing machines can be set to weigh accurately, providing other elements of the installation are proper."

As the Pittsburgh and Lake Erie has as good a scale installation and secures as good results as any road, a letter was written Mr. A. R. Raymer, assistant chief engineer of that company, regarding this point, and his reply was as follows:

"The gradient of approach on scales, and run-off for gravity weighing, should be determined by the method of weighing. If the weighing is to be

done by hand, it has been found that the speed of the car should not exceed from one to two miles while on the scales; the grade of the approach to be made to produce this speed. Where automatic devices are used for recording the weights and the proper design of scale is used, the speed of the car can safely be as high as four or five miles per hour while on the scale. This is the speed used by our company and the gradient that produces it is as follows:

"0.6 per cent on the scale. This grade to extend to a point 10 ft. above the upper end of the scale, and 55 ft. of 2 per cent grade above that point to the knuckle. The grade below the scale will be determined by yard requirements."

Mechanical Hump.

We may mention Mr. Epright's device called a mechanical hump, shown in Fig. 58. For the illustration and the following description we are indebted to the Railway Engineering & Maintenance of Way. This device is of merit where hand weighing is done, as the difference in speed of cars between extremes of heat and cold on a hump with fixed grade is a serious matter to the facility with which hand weighing is done:

"The object of the mechanical hump is to provide a simple and effective means whereby, with the minimum of attendance, cars may be passed rapidly and without stopping over the platform of the scale with the proper velocity to permit each car to be weighed regardless of variations (within usual limits) in the lengths of successive cars. To accomplish this, the track over which the cars pass to the scale platform is provided with a hump having a fixed apex at a short distance from the adjacent edge of the scale platform so that when the cars are pushed at a uniform rate up the side of the hump remote from the scale, and are uncoupled from each other, before or while being pushed up the hump, each car will run down the hump and on the scale platform with the proper velocity to permit it to be accurately weighed.

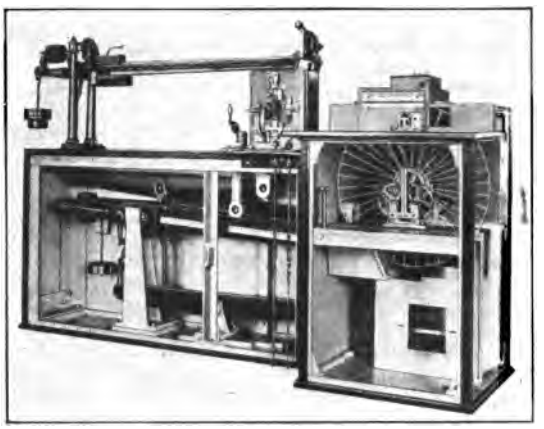
"The hump has been so constructed that the elevation of its apex above the scale platform can be adjusted in order to get the desired relations between wheel base of varied cars ensuring proper rates of speed of the cars. For instance, the elevation of the hump required in a given installation depends on and changes with the season. In winter, when everything is taut from contraction, the apex of the hump should be somewhat higher than in the summer, when the cars are somewhat less rigid and the lubricant is more fluid."

Automatic Recording Devices.

The Streeter-Amet weight recorder is commonly spoken of as a weighing and recording device, but as it does not weigh, but merely records the weight as given by the scale, and is in no way independent or corrective of any errors of such scale, the title above is used. It may be described as "a mechanical device designed for the purpose of automatically recording the weight of a loaded or empty railroad car, that is transmitted to it by means of a series of multiplied levers constituting a track scale."

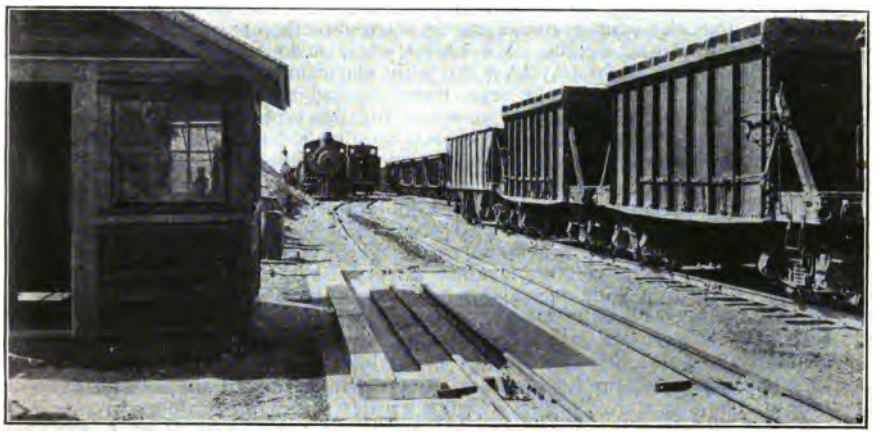
The device may be divided into two distinct mechanisms, which are so designed and constructed as to work in harmony with each other. One of these mechanisms consists of a helical spring, rack, type wheel, shaft and pinion, roller bearings and dash pot, the purpose of which, by combined action, is to indicate the amount of weight scale borne. The lower end of the helical spring is securely fastened to the machine at the base, while the upper end is connected to the lower end of the rack which in turn is extended upwards by means of a steel rod, which is connected to the scale beam. The type wheel is fastened to the shaft, the journals of which rest on compound roller bearings. On this shaft is located the pinion, the teeth of which engage

those of the rack. On the periphery of this wheel is placed the recording type with graduations corresponding to those on the scale beam. This wheel is so set that when the scale is empty, and the beam is at its lowest position, zero is the uppermost point on the wheel and is indicated by an arrow or dash, fixed permanently in close proximity to the rim of the wheel. When the car becomes scale borne the beam rises and stretches the spring, until the resistance equals the power applied and the beam is brought to an equilibrium. The vertical movement of the rack is converted into a rotative one in the type wheel by means of the pinion, hence the movement of the rack and type wheel are directly proportional to the weight on the scale platform. The roller bearings reduce to a minimum the friction in the movement of the type wheel. The dash pot consists of a cylinder filled with kerosene oil, and a piston equipped with accurately adjusted triple spring valves. This piston is connected to the end of the scale beam and moves vertically through the oil in synchrony with the beam. The purpose of this dash pot is to absorb the shock caused by the sudden application or withdrawal of the weight on the scale rails, and thereby prevent any damaging jar from reaching the mechanism of the dial, and thus assist the beam in quickly finding an equilibrium.



New Type, Streeter-Amet Weight Recorder for Railway Track Scales, 300,000 lb. Capacity. Interior view, showing recording mechanism, auxiliary beam and counter mechanism. The standard beam on top of casing is out of service when the recorder is in use.

The other mechanism consists of a series of gears, cams, pawls, levers, wires and a printing hammer, the purpose of which is to automatically record the weight indicated by the mechanism previously described. This mechanism is arranged and connected, so that a small knee lever, or levers, placed on the scale platform, just inside the scale rail, is operated by the flange of the wheel passing over it, and through the above described mechanism releases the printing hammer causing an imprint of the indicated weight to be made on the card waybill or a paper tape. The tape is unwound from a spool at the rear of the recorder box and passes across the top of the box and the periphery of the recording wheel, being automatically wound by means of a clock spring motor into a compact roll as each weight is recorded. The imprint is made by use of a carbon paper disc located directly under the printing hammer and over the tape. The space between each print on the tape is about four inches, giving ample room for the notation of necessary data,



Scale Plant of the Nevada Northern Railway, at McGill, Nevada, arranged for weighing cars of copper ore, coupled. Equipped with Streeter-Amet Weight Recorder. Photo shows trips at each end of scale, for coupled weighing, and customary manner of housing the trip connections.

Interior view of Pittsburgh & Lake Erie Scale House, at McKee's Rocks, Pa. Standard type Streeter-Amet Automatic Weight Recorder, 200,000 lb. capacity, connected to scale beam. Beam is a special pattern, made by the Fairbanks Co., for use with the Streeter-Amet recorders. The recorder is equipped with temperature controlling device.

such as car initial and number and tare weight as each car is weighed. Where the weight is printed on the card waybill each card must be inverted and inserted into the receiver located directly under the printing hammer, by the weighman. The imprint is made by an inked ribbon which passes across the periphery of the type wheel and under the card. The card receiver is so adjusted that the print is made on the card directly opposite the space intended for the gross weight. The knee lever is so located as to give the car the greatest distance of travel on the scale platform, after becoming entirely scale borne, and to allow the scale levers to find an equilibrium before recording the weight. The time required for the type wheel of this device to find an equilibrium after the car becomes scale borne depends upon the multiple of the scale and method employed in weighing, and varies from one to three seconds.

Since the recorder is connected to the scale beam which is the last link in a series of multiplied levers used in transmission of the weight from the scale rails, it differs from a spring scale, which sustains the full weight on the spring, by only reacting against a very small proportion of the full weight. This proportion depends upon the multiplication of the several levers, varying from .00008 to .00004 of the weight applied. It is not truly a spring scale, but is a spring controlled recorder, the accuracy of which depends primarily upon the accuracy of the scale whose work it records.

The makers claim for this device: the elimination of the human equation in obtaining and recording weights, greater speed and economy in weighing, an automatically printed original record of the weight of each car, a means of detecting certain imperfections in the scale, and a higher percentage of efficiency. The elimination of the human equation insures greater accuracy by removing the possibility of error likely to occur in the operation of the poise by hand, reading the beam and recording the result. The action of the recorder will readily indicate certain imperfections, as, broken parts, deflections, friction or interferences.

To use this device successfully it is absolutely essential that the scale be in first class condition, with properly maintained approach track and cars run at a slow rate of speed with particular attention to steadiness of motion. The errors of usual rating of scale capacity shown before must be borne in mind, and the scale must be designed for the concentrated load it will receive, and the weigh bridge and scale levers must be of such rigidity as to prevent deflection. The approach tracks must be properly graded and well surfaced and kept in that condition. Cars must move over the scale steadily and smoothly as possible to the end that as far as possible causes of vibration be eliminated. Uneven track or open joints between scale and track rails cause the cars to pound and start vibration. For this reason the hump track and easer rail add greatly to the accuracy of scales in this work.

There are three methods of handling cars in weighing with the automatic recorder. Coupled in train and drawn over the scale by an engine. This is used in level yards where cars are weighed in trains intact, before classification. It is used in weighing live stock at the various stock yards and in weighing iron ore at Lake Superior points. Cattle might be injured by any attempt to spot the cars for weighing by hand. Some dissatisfaction has been expressed by those using the device in this service. Cattle do not remain at all times quiet in a car, and if the cattle get to "milling" in one car while on the scale it may start vibrations which will affect not only the recorded weight of that car but of those immediately following.

As to the weighing of iron ore, we have the following from Mr. W. A. Clark, chief engineer of the D. & I. R. Ry.: (The scale used by this company is shown in Fig. 48.)

"Our ore cars are all of steel construction, 24 ft. long between centers of couplers and are of 50 ton nominal capacity, weighing from 29,000 to 33,000 lbs. When loaded with some of our heavier ores, the gross weight of the car is frequently 150,000 to 160,000 lbs. The wheel base of the cars is from 18 ft. 6 in. to 19 ft. 8 in., and the wheel base of the trucks is from 5 ft. to 5 ft. 7 in.

"Our ore scales are located on tracks which are used practically for nothing but weighing ore, and at a point where approximately 80 per cent of our ore is weighed. This track is long enough to hold three full trains above the scales, and one full train after passing the scales. This is necessary because sometimes two or three ore trains arrive closely following each other and pull in this scale track to clear the main track while the train ahead is being weighed. This track is on a grade of about .06 per cent. The grade is quite uniform for over a train length and the track is maintained in first class surface, so that the movement over the scales will be smooth and with as nearly as possible a constant, though slight, tension on the draw bars. At Ely, where the remaining 20 per cent of our ore is weighed, the track is about 1,300 ft. long and practically level at the scales. The engines at the head of our ore trains run over the live rails of these scales, as it would be rather impracticable to use them in connection with a dead rail and would cause considerable delay, which we think unnecessary, as the engines run over these scales very carefully and we do not find that they do any noticeable damage."

This company uses the Streeter-Amet recording machine and recommends it for such use. A test of 53 cars weighing close to 150,000 lbs. each weighed in train as above and then spot weighed by hand showed that 21 cars checked exactly, 22 weighed light an average of 180 lbs. and 10 weighed heavy an average of 210 lbs. The 53 cars weighed over 7,500,000 and the total difference between the two weights was 1,800 lbs.

H. L. Dresser, chief engineer D., M. & N. Ry., writes: "Our ore cars are 24 ft. center to center of draw bar. Our ore scales are placed in the Proctor yard on an independent track, which is kept for the purpose of weighing ore trains. There are two scales and each has its own track. The tracks are level for some 300 ft. on approaching the scales and level for about one train length after leaving the scales. There is a grade of about .2 of 1 per cent for some distance back on approach to the scales. The ore is all weighed while the train is in motion and we use a Streeter-Amet recorder to record the weights. These scales are checked every morning during the ore season with a test car, and they have frequently been tested by weighing the train moving, and then going back and weighing the cars separately, but when the scales are in proper adjustment, as they usually are, there is no appreciable difference in the weights as between the moving train and the standing cars. Of course the train must be carefully handled and kept moving at a slow but uniform rate of speed. The engines run across the live rail of our two ore scales and our coal scale, as neither has any dead rail. The trip is placed six inches from the end of the rail. Our trains pass over the scales while weighing at the rate of about two miles per hour, hence the weight of the car would be on the scale rails about five seconds before the trip starts the recording machine."

It was hoped to have some records of these scales for this report, but they have not been received.

As will be inferred from the above quotations, with this method of weighing, it is necessary that the scale be of proper length to accommodate the greatest percentage of cars possible and installed in a location which will provide for straight track of a uniform gradient, as nearly level as possible for at least the length of the train to be weighed. It is essential that rails at either end of the scales be kept in perfect grade and alignment to prevent draw bar friction. The speed of the cars must be even and free from jerks. This method cannot be used in weighing miscellaneous equipment, but cars must be of uniform length and the length over centers of coupler must be the same as length of scale. Cars too long or short must be weighed separately.

This device is most frequently used in gravity yards. For this use it is recommended that a scale be one third longer than the wheel base of the longest car to be weighed in ordinary service. Most of the roads seem to prefer 50 ft. or 52 ft. scales for this use. Good results are obtained with 46 ft. scales in the eastern Ohio region where the gondola type of coal car is

largely used. As illustrating the best practice in this regard, the following by Mr. A. R. Raymer of the P. & L. E. is submitted:

"In order that you may understand the results obtained by the use of this scale I may state that the scale at Glassport, which was the first of the kind installed, was completed in May, 1908. Since that time it has weighed over one million cars, principally coal, at an expense for maintenance of not over $20. From present indications the scale will weigh as many more cars without being necessary to renew any of the knife edges or any other parts of the scale. We can at any time spot weigh a string of cars by use of the beam and afterwards weigh the same cars running at a speed of five or six miles per hour, using the Streeter-Amet device and have the same weights recorded.

"During the four and one half years this scale has been in use it has not been necessary to adjust it once, and the variation has at no time been greater than 20 lbs. on any section.

"In regard to the comparative accuracy of gravity weighing by hand and gravity weighing by use of automatic recording device:—Assuming that the scale is properly designed, that is, that it is of sufficient strength and properly braced and has approach rails designed to allow the car to pass on and off the scale and not cause vibration in the beam, I am convinced that accurate results can be had by the use of automatic recording devices; but under conditions other than these it is not entirely safe to use such devices, particularly where conditions are such that the car is vibrating vertically while the weight is being recorded. This installation carries with it of necessity a device which prevents inaccurate weights from being recorded on account of conflicting cars, either above or below. When such cars conflict the device will cut out the weight entirely, that is, no weight will be recorded under these conditions. When all of these things are provided for I am convinced that the automatic device is preferable and very much to be desired, as it cuts out the possibility of making large mistakes; and in addition the cars can be handled at a speed of four to five miles per hour, whereas under other conditions where weights are to be taken by hand, the speed should not be over 1½ to 2 miles per hour. The hand weighing is also complicated with the conditions which have to be recognized, that when the weight is not properly determined it is usually guessed at, as the weighmaster is not likely to have the yardmaster bring the cars back for a second weighing. We have repeatedly weighed cars spotted, then reweighed the same cars running over the scales by the use of the beam by hand and again reweighed the cars by the use of the automatic device, and in all cases we have gotten accurate results by the use of the automatic device."

The method of weighing cars by drifting over the scales is used principally in yards having but slight grades and cars are moved in one direction over the scale. The cars are pushed over the scale and each car is cut as it enters the scale platform, and allowed to drift away from a slowly moving train. The advantage of this method, as claimed by the men working in the yards, was the dispensing with car riders, an item of much expense and delay in gravity yards. Mr. L. L. Sparrow, engineer of roadway, Atlantic Coast Line, writes as follows of their scale at Port Tampa, Fla.:

"Our scales at this point are used principally in the weighing of cars loaded with phosphate rock to be handled through our elevators. On account of the plan of the yard we were not able to build our scales exactly as I think would be desirable. We use the Streeter-Amet automatic weighing attachment, and push the cars over the scales, the switchman cutting off each car just before it reaches the scales and allowing it to roll away into one of the three tracks at the foot of the grade. Our scales are 40 ft. long and are set perfectly level with 30 ft. of level track on each side of the scale, with 0.3 per cent descending grade for 650 ft. after leaving the scales. I do not consider this a sufficiently heavy grade and it would not be sufficient in a cold climate, but under the conditions it was the best we could do, as I could not elevate the track any more on account of adjacent tracks. If the

equipment is in first class condition, the cars roll away readily, but we frequently have cars which do not roll to the foot of the grade and makes it necessary for the switch engine to handle them before they have completed weighing a full string of thirty cars. This also occurs on days when we have a high wind blowing in a direction opposite to which the cars move. We had a 0.3 per cent ascending grade to a point 30 ft. from the scales, but we found it better to increase this grade to about 0.6 per cent and carry it up so that there is a slight descending grade toward the scales. If conditions were such that it would be practicable I would advocate having a descending grade of about 0.6 per cent to a point about 40 ft. above the scales, level across the scales and about 40 ft. beyond, and then a descending grade of about 0.6 per cent. The grade should be increased in colder climates."

Mr. R. W. Romig, of Pittsburgh, was for many years a scale inspector in New England and the middle states. Two years ago he made a report for one of the railroad companies at Pittsburgh and a number of extracts are given in this report. In speaking of recording machines he writes:

"You will understand that they are very delicate and sensitive. They work with a rack pinion and springs. At points where they connect with the scale proper, multiplications are often as high as 10,800, so that one pound on the point of connection equals 10,800 lbs. on the scale platform. This condition makes it necessary to take every precaution to prevent wear on the racks and pinions and also sudden shocks and jerks on the springs. The shock and jar also starts the scale levers trembling. This trembling is immediately transmitted to the scale beam and recording machine. Scale beams where automatic recorders are attached should always be a single beam and very rigid. Temperature in scale houses where recording machines are installed should be kept uniform. Recording machines can be set to register accurately under different temperatures, but they will record accurately only within the range of temperature they are set for. Variations of ten degrees are noticeable."

At one installation a thermostat was placed in the box of the recording machine, and the changing temperature kept it constantly flashing. It does not seem that your committee should go further in this matter. Numerous data have been secured as to the comparative accuracy of machine and hand weighing, the hand weighing being both in motion and by spotting. These figures seem to indicate that with gravity or float weighing the machine results are the more accurate. With the machine working with the train drawn across the scale with cars coupled, the results are less exact than with gravity weighing. The maximum results agree very closely with the individual weighing, but there are a very large number of the cars showing differences of from 200 to 400 lbs. to the car. This discrepancy is not proportional to the load, but varies as much with a light car as with a heavy one.

Type Registering Devices.

This device is different from the last in all but one feature. The weight, as determined by the operator adjusting the poise on the beam, is printed by manual operation of the poise lever on a card. It assures accuracy in but one feature, that the exact weight to which the poise is adjusted will be printed on the card. It does not assure that the weighman will bring the beam to a true balance. It does not assure that he will not use his free hand to bring the beam quickly to a rest. It does not assure that a portion of a car other than the one being weighed will not be on the scale rails when the record is taken. It does guard against errors in reading the beam and in transcribing them. It is a device within the sliding poise which always presents at a fixed spot the figures shown on the beam at that spot. These type figures are hard metal, usually bronze, and by a movement of a lever on the poise the figures are imprinted on a card placed in an opening in the poise. The slot in the poise for receiving the card is of such size that the figures are imprinted on the proper line on the card. The device is so simple and subject to so few accidents that no detailed description is needed. These

are made with small differences by Fairbanks, Howe, Buffalo and Strait scale companies. The cards may have prepared carbon slips attached to them for making duplicate copies. Where this is done one is usually gummed on the back for attaching to the waybill. The Standard Scale Co. make a device which punches a hole in a card on which a series of weights has already been printed, punching the number corresponding to the weight on the scale beam. The following opinions of the device are presented:

R. W. Romig.—"Where automatic recording machines are not attached, it has been proven that more errors occur from misreading the beam than any other condition which exists at the present day. Where recording beams have been installed causes for short and overweight have always been traced to defective scales or faulty installation. The recording beam gives a positive record which can always be referred to. On roads where this has been experimented with, recording beams have proved to be the only remedy."

F. J. Huffman.—(Western Railway & Inspection Bureau.) "As to the equipment of the scale, there is absolutely no question but that every scale should be fitted with a type registering beam of full capacity with manifold paster tickets on which to record the results of weighing. On these tickets the weight is registered by the weighmaster, who pulls the lever in the device which slides on the beam. The lever, however, should not be pulled until the beam comes to a balance. This records the gross weight. The tare should be inserted in the same ticket with an indelible pencil and carefully deducted from the gross, the net being shown in the space provided therefor. Other information for which spaces are provided should be likewise shown and the ticket signed by the weighmaster, personally. This, you will note, creates a permanent record. The slip which is provided with a gummed back is carefully attached to the waybill either by the weighmaster, or in the agent's office as is most convenient. The pasteboard back of the ticket and one of the carbons are also retained as a permanent file. The third copy is for incidental use in connection with overweight claims or for such other purposes as may be desired. We have found that the use of this device for recording weights has done more towards the elimination of clerical errors than any other plan or method which has ever been adopted in connection with carload weighing service. It also eliminates the possibility of error in reading the beam and its value in connection with any track scale is, we believe, far in excess of its cost."

The face of the scale ticket mentioned above is shown below:

Western Railway Weighing Ass'n.
Scale Ticket. No._____

Date Weighed _____ m. Initials _____

Car Weighed Uncoupled at _____ Car Number _____

_____ Gross.	Dry	Wet	Raining	Snowing	Sleeting
	Date of Tare		Temp. Fixts.	Gr. Doors	Stakes
_____ Tare.	Refuse	Ice in Tanks	Racks	Blocking	Dunnage.
_____ Net.					

Capacity _____ _____
Signature of Sworn Weighmaster.

F. C. Maegley.—(A., T. & S. F. Ry.) "Our track scales are equipped with type registering beams. Cars are weighed standing free and uncoupled at both ends. The beam is brought to an exact center balance by the sworn weighmaster, who then inserts the scale ticket in the slot in the beam, pulls

the printing lever, and by this means imprints on the scale ticket with the type on the beam the gross weight recorded. We use manifold scale tickets, samples of which I am enclosing. The reason for using these tickets is twofold. In the first place we make it absolutely sure that we get the actual weight recorded by the beam at the exact balance, and not a weight erroneously read by the weighmaster. In the next place, we have the original scale ticket on which the weight has been imprinted, to attach to the waybill, and do not run the risk of error caused in so many cases in reading the beam, and in transcribing the figures into the scale book and then probably into some other record, and then finally on the waybill. Our instructions as to weighing cars are printed on the back of the ticket."

This scale ticket is the regular form adopted by the Western Weighing Association and given above. The rules are as follows:

"Instructions to Weighmasters. Know that the scale is in weighing order. Keep the scale platform and live scale rails free from bind or obstruction. Keep the scale beam, beam notches and poise free from dust, dirt, grease and rust.

Always balance the scale before weighing. Weigh each car carefully. Make first record of weight on scale ticket. Print the weight on the scale ticket with the type registering beam only when the car is actually on the scale and then only when the scale beam is at proper balance.

Each car must have full clear bearing on the scale and be weighed standing uncoupled and free at both ends. Weighmaster must personally see that each car is placed on the scales, is uncoupled and in the clear, and not depend on the yardmen to do this for him.

As each car comes on the scales, and not before, the weighmaster must enter with a sharp pointed indelible pencil the "Initials," "Car No." "Tare," "Date of Tare," and "Capacity." Weighmaster must mark the weather conditions with a cross (X) in space provided for "Dry," "Wet," "Raining." "Snowing," "Sleeting," as the case may be. Show "Date of Tare" by month and year. Show actual number and approximate quantity of "Refuse," "Ice in Tanks," "Temporary Doors," "Stakes," "Fixtures," "Racks," "Blocking" and insert the nearest possible estimate of the weight thereof.

In space for "Date Weighed," record the hour and "A. M." or "P. M." of weighing.

The weighmaster must personally weigh each car and sign his own name to the scale ticket.

Yardmaster, engineer, foreman, switchman, conductors or trainmen coming to the scale with cars to be weighed, must coöperate with the weighmaster by placing each car on the scale, uncoupled at both ends, and giving the weighmaster ample time to weigh carefully and to accurately record results.

Keep tickets in a dry place. They must not be wasted."

Most of the above matters are out of our jurisdiction, and the matter is for information only, yet we cannot but regret that the American Railway Association does not embody the next to the last rule above in their standard code and the roads insert it in their book of rules. The men mentioned do not see the back of the ticket, and do not care much if they did. Were it in the book of rules and impressed on the men by train rule examiners it would make the lot of the weighman easier and the weights more accurate.

Scale Beams.

Such of our correspondents as expressed an opinion concerning scale beams advocate a steel beam as it is thought that the required stability is not to be obtained by any other metal. One correspondent recommends a beam of cast iron with a steel bar doweled in with graduations on the steel bar. The numbers are preferred on brass, but some advise japanned white on steel.

The beam should be so rigid that under working load applied in a testing machine, the deflection of the tip from the line of the pivots shall not exceed one tenth of an inch.

For some hand work a double beam is preferred. The weighman sets off the tare on the upper beam, and gets the weight of the contents on the lower beam without any computing.

For using with the type registering attachment a special beam is necessary. All scalemakers furnish these.

Where a Streeter-Amet recorder is used best results will be obtained if the multiplication to the butt of the beam is not over 400. A multiplication of 800 is common for hand weighing.

INSTALLATION.

It seems proper at this point to summarize the rules for installation as adopted by the American Railway Association last May. Scales should be installed with dead rail or relieving apparatus. The deck of the scale should be of the rigid type and should be as nearly dirt and water proof as possible. Scales for spot weighing should have the scale rails level and approach rails level with them for a distance of at least fifty feet. For motion weighing scale rails should have a grade not greater than one per cent. Means of adjustment used to secure a uniform distribution of loading should be set low as possible when installing as yards are raised more than lowered. Wooden ties between weigh bridge and scale rail are recommended, and should not be framed until bridge is installed. Scales should be set directly on foundation or on metal bed plates resting on foundation. The anchors provided should have slight adjustment laterally and longitudinally to permit changing of scale parts. Scale beam supports should rest directly on foundation. A clearance about working parts of the scale should be ¾ inch except that rails of approach when properly anchored may have not less than ½ inch. An easer rail will be permitted if arranged so as not to interfere with action of scales. Approach and scale rails should be anchored so as to prevent creeping. Scale pits should be heated. Ventilation of scale pits should be provided. Scale pits should be lighted. Scale houses are recommended. Adequate lighting inside and out of scale house should be provided where night weighing is done.

The above are abbreviated somewhat. These rules also recommend cut stone or concrete foundations laid in accordance with best engineering practice, and the provision of adequate drainage either natural or artificial.

LOCATING SCALES.

It may be well at this time to consider the matter of locating the track scales. First should be decided the type of scale and pit; if the scale is to be used for spot or motion weighing; whether it is to have overhang to the scale rails, and if so how much; whether or not a dead rail is to be used, and if a pocket track is to be provided. With these points decided, it is well to have a consultation with the yardmaster and others likely to be interested in the use of the scale, as in this way some points may be brought out which would affect the location of the scale. Prominent factors to be considered in the location are: convenience in switching, facilities for handling cars between the scale and the yard tracks, track connections, gradients, alinement, track spacing, drainage of scale pit, length of scale tracks, etc. The scale tracks should be of convenient length, but not so long as to be wasteful of storage space in the yard. The location of the scale should be such that trains using it will not interfere with streets or road crossings.

Plans and profiles should be made by the engineering department, and should contain all the information required for preparing the estimate of cost. The cost and the amount of construction work may vary considerably, according to whether the scale is to be used for spot, float or gravity weighing. The location and grade of the scale track and pit, and also the drainage system, should be set out on the ground by the engineering department.

Special consideration is to be given to the drainage and foundation, and if there is doubt as to proper natural drainage or as to the bearing power

of the soil, a test pit should be dug and the soil formation noted. The elevation of ground water should be ascertained also, and levels taken along proposed lines of drains from the scale pit to the outlet. If this outlet discharges into a natural waterway, note should be made of the high, low and ordinary elevations of the water line, and their relations to the grade and elevation of the drain and the pit. Where a tile drain is used, it should start with its upper end not less than 6 in. below the bottom of the scale pit, and should have sufficient fall to give free flow for the water. Grades of 4 to 7 in. per 100 feet are used in many cases. If proper drainage cannot be obtained, the scale pit should be made thoroughly waterproof and a sump and pump provided for removing any water that may enter.

For the foundation, if test pits are not dug, the soil should at least be sounded with rods to determine its character and sustaining qualities, and the foundation proportioned accordingly.

The St. Louis & San Francisco Ry. adopts the following assumptions for a 50-ft. 150-ton track scale:

Load on side wall next to scale house, 3½ tons per lin. ft.
Load on side wall opposite scale house, 2 tons per lin. ft.
Load on two end piers supporting lever stand, 76 tons each.
Load on two centre piers, supporting lever stand, 102 tons each.
Load on two end walls of pit, supporting ends of scale rails on approaches, 30 tons each.

This road also uses the following as safe loads for different materials:

	Tons per sq. ft.
Rock, the hardest, in thin layers, in native bed,	200
Rock, equal to ashlar masonry,	25 to 30
Rock equal to the best brick masonry,	15 to 20
Rock equal to poor brick,	5 to 10
Clay, in thick beds, always dry,	6 to 8
Clay in thick beds, moderately dry,	4 to 6
Clay in thick beds but soft,	1 to 2
Gravel and coarse sand, well cemented,	8 to 10
Sand, dry and compact, well cemented,	4 to 6
Sand, clean and dry,	2 to 4
Quicksand and alluvial soils, etc.,	½ to 1

Sufficient room should be provided for a scale house without interfering with adjacent tracks. The rules of the road as to clearance should be borne in mind. It is well to set the scale a foot or more above the adjacent tracks, so that when tracks are raised (as they often are) the scale will not be left in a depression. The live rails are best made on a tangent, the dead rails making the necessary diversion. The track for at least one car length in each direction should be tangent to the scale track, and for spot weighing it should be on the same gradient as the scale.

The bill for the scale should include the following:

Complete track scale.
Weigh bridge.
Complete outfit of beam, stands, shelf and shelf supports.
Type registering beam, if desired.
Live rail stands, steel buffers, plates, bases and rail clips.
Rails, tie plates, bolts, nut locks, etc.
Anchor and other bolts, dowel pins, washers, screws, etc.
Cement, sand, broken stone or other aggregate.
Lumber for forms, scale house, etc.
Creosoted ties to use under scale bridge.
Drainage material; (or if natural drainage be impossible, waterproofing material and a pump.)

In order to avoid joints, it is desirable to provide track rails the length of the platform for scale rails and two feet longer for dead rails.

All material (unless it be the scale mechanism and the weigh bridge) should be assembled before a force is sent to install the foundation. In all cases the engineering department should be in charge of construction of the scale pit, foundation and drainage. Excavation for the scale pit should not be started until materials for forms and pit walls are at the site, except that where natural drainage is used the drain tile should be laid before the excavation of the scale pit is begun. Before work is started on excavating the pit, carpenters should be arranged for, to build the forms for concrete work. They should be on the ground the day that the excavation is completed. The excavation should be protected with fence and lights to prevent persons from falling into it. Concreting should be done with the aim of making walls, piers, etc., as nearly monolithic as possible. All parts should be finished to correct line and grade. Owing to small inequalities of castings it is well, if

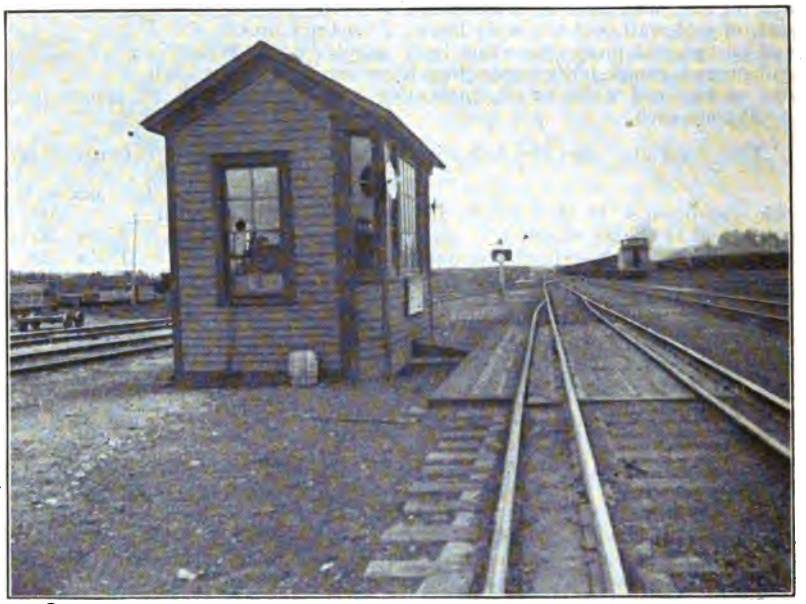


Fig. 59.—Duluth, Missabe & Northern Scale House.

length of anchor bolts will permit, to surround the upper foot or so with a piece of old boiler tube to permit a slight play of the bolts. Great care should be exercised in setting the anchor for the fifth lever, as this is the center of the scale.

The walls and piers should be built the required level, with an allowance for shrinkage. The top is best finished with 1 to 1 cement mortar, 1½ in. thick. Time must be allowed for the proper setting of the cement (which is ordinarily not less than 10 days). Then the castings should be set with a level being used to ensure their accuracy.

The installing of the scale and weigh bridge and placing of the rails on the scale and approaches should be done by an experienced man. If the scales are bought subject to an acceptance test, this work should be done by a representative of the scale company.

RULES FOR INSTALLING SCALES FORMULATED BY THE MINNESOTA RAILROAD AND WAREHOUSE COMMISSION.

Location.

Lead to Scales:—Scales must be so located that at least 40 ft. of straight track may be secured at each end; except that where the scale is to be used from one end only, 40 ft. of straight track must be provided at that end.

Dead Rail:—Dead rail must be provided in all cases where the scale can be approached from both ends.

Space About Scale House:—Where a scale house is necessary, that is when the scale beam is not extended into a building, such as a mill or elevator, provision must be made for a space of at least 9 ft. between the scale house and the center of any track that may pass beside the scale house.

Drainage:—In all cases proper drainage must be secured, so that water will not remain in the pit.

Foundation.

Depth:—All foundations must extend to at least 9 ft. below the surface, and where rock formation is found, said rock must be taken out to furnish a pit at least 7 ft. deep. The bottom must have a smooth coat of cement and must be slanting from all sides to the point of drainage.

Height Above Ground:—All scales must be set high enough on the foundation that surface water will not drain into the scale pit.

Piling:—If the foundation must be placed in soft, marshy or filled ground, piling must be driven to secure a solid footing. At least four piles must be driven under each bearing pier of the scale, and a sufficient number under the walls to prevent settling.

If not on rock, a 24-in. concrete mat must be laid somewhat larger than the outside walls, and the outside walls and bearing piers must be formed to and rest upon this mat.

Side and Neck Walls:—The side and neck walls must be at least 24 in. thick at the bottom and at least 18 in. thick at the top; the batter being on the outside of the wall, and the surface of said batter must be smooth.

End Walls:—The end walls must be at least 7 ft. thick at the bottom and 6 ft. thick at the top; batter on the outside and batter smooth.

I-Beams on Side Walls:—Provision must be made in the top of the side walls for placing I-beams on which the top planking of the deck shall be laid, and to which a dead rail can be secured. When dead rail is used, these I-beams must be of sufficient size and number to carry the load, but if they are to serve as supports for top planking only, their size and number can be reduced. These I-beams must have a bearing of at least 12 in. on each side wall and the space between their ends must be built in with brick even with the inside line of the walls.

Scale House:—The so-called "neck walls" must be a solid extension of the side walls next to the scale beam, and must extend far enough to form a foundation for full size of scale house. This house must be not less than 4 ft. wide and, of course, long enough to cover the scale beam without touching the shelf thereof.

Piers for Scale Section Frames:—The foundation piers for the scale section frames to rest on must be set at least 16 in. from both end walls and side walls, and these piers are to be built up to a proper height so that the scale section frames will rest on them at a proper height without the need of timber, steel or shimming of any kind. Piers are to be finished smooth and to have a 4 in. batter on all sides. The top of the pier must be 4 in. larger each way than the casting that rests upon it, and must be beveled away from the edges of the castings so as to leave no horizontal shelf for moisture and dirt to collect. There must be three piers for each scale section frame; one under each end casting, and one under each center casting of the frame.

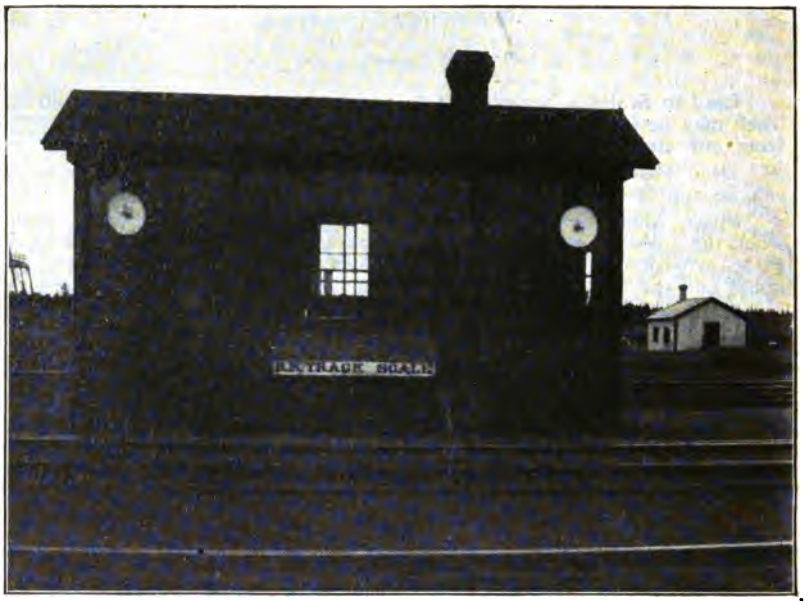


Fig. 60.—Duluth, Missabe & Northern Scale House, Showing Lighting Fixtures.

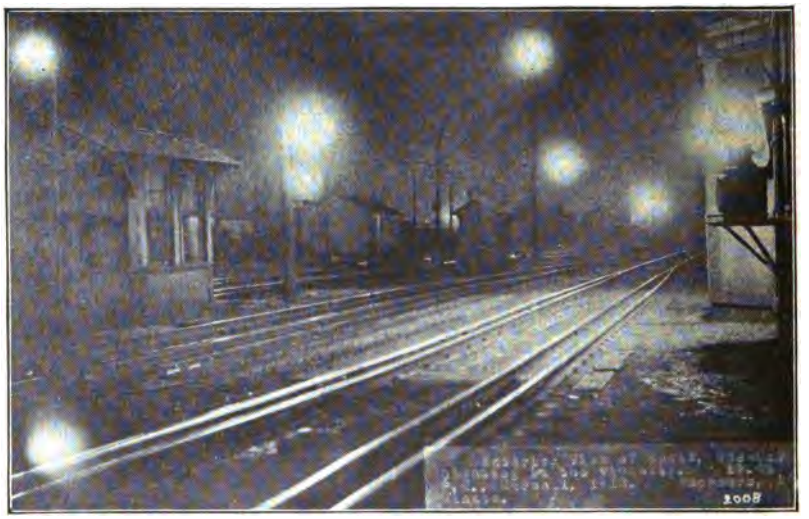


Fig. 61.—Exterior Lighting, Pennsylvania R. R. Track Scales.

Anchor Bolts:—Anchor bolts must be set in the piers to match all bolt holes in the scale section frames that are to rest upon them.

Recesses in Piers for Main Levers:—If the scale is of the type that has main levers that hang below the scale section frames, recesses for the butt of main levers must be left in the front of each side pier. These recesses must be of a size to give a clearance of 1½ in. around the levers, and must be so formed that the bottom will be on an angle of 45° downward from a point under the butt of the main levers.

Anchorage of Floating Levers:—If there are any floating levers in the scale (that is, any lever the pull on which is upward at the fulcrum), steel rails or I-beams must be built into the bottom of the foundation mat, in the proper position to receive the fulcrum eye-bolt or anchor bolts as the case may be.

Setting of Scale.

Levels:—The scale section frames must be set square and level on the concrete piers, and lined up to center. All these frames must be secured to the piers by the bolts already provided in the piers, and the nuts must be drawn down tight.

Fig. 62.—Interior Lighting, Pennsylvania R. R. Track Scales.

Plumb Lines:—All connections must pull perfectly plumb and all pivots must be driven tight.

Scale Beam:—The scale beam must rest on a shelf placed on iron pillars and must be supported by iron stands that rest on this shelf. No part of the shelf, pillars or beam supports must touch the side walls of the scale house.

View of Scale:—The scale beam must be so placed that the weigher, when weighing a car, will stand in a position facing the scale platform and have full view of it.

Live Rail Platform.

Size of Live Rail Platform:—The platform must be made up of steel I-beams tied and braced together with steel cross bars; I-beams are to be not less than 18 in., and heavier I-beams are very desirable.

Bearing Plates:—The bearing plates must be bolted to the platform

I-beams so that the bearing plates rest properly upon the main lever pivots, and all bearings must bear equally upon their respective pivots when the platform is in place.

Checks:—If check rods are used, they must be level and have ⅛ in. play when the scale is loaded or light.

Short Pedestals:—The platform or live rails must be securely bolted to short cast iron pedestals which rest upon oak ties bolted to the platform I-beams. The space between live rails and solid deck (which space must be not less than one inch) must be protected by 2 in. strips of wood nailed to the solid deck, and of sufficient height to be level with the top of rail flange.

Protecting Strips:—On top of the wood strips are to be steel protecting strips in about 5 ft. lengths. These are to be 6 in. wide and ¼ in. thick, one edge resting on the wooden strips and the other edge on the live rail flange. It is held in place as a hinge by staples of ⅜ in. iron passing through ½ in. holes in the edges of the steel strips, two staples to each strip.

Solid Deck.

Solid Deck Clearance:—The flooring of the solid deck must be of 2 in. plank, surfaced and matched. A 2 in. clearance must be given in said deck around each live rail pedestal, and also ample clearance between the bottom of the solid deck I-beams and the top of the live rail platform I-beams.

Switch Points:—Switch points must be used at the ends of the live lead rails and must be fastened to the end walls by bolts set in these walls. The dead rail (if used) must be securely fastened to the end walls by bolts. This arrangement is necessary to prevent the lead rails from crawling toward the scales and producing a binding effect against the ends of the live rails.

Type Register Beams:—All scale beams must be type registering and full capacity beams. No extra or additional weights to raise the capacity, and no loose weights, will be allowed.

Counterbalance Weights:—The counterbalance weights (if used) must not be slotted, but must be furnished with a hole in the center through which the hanger stem shall pass and the cup for balancing the scale shall be below these counterbalance weights, with the weights resting on top of the cup.

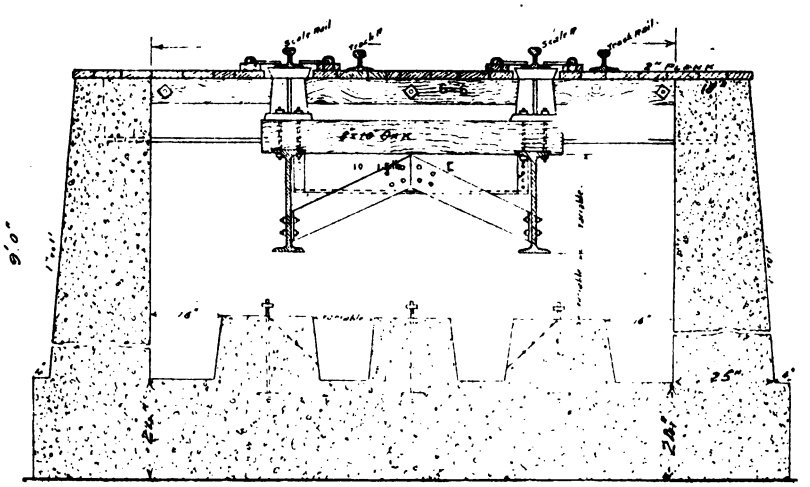


Fig. 63.—State of Minnesota Scale Pit.

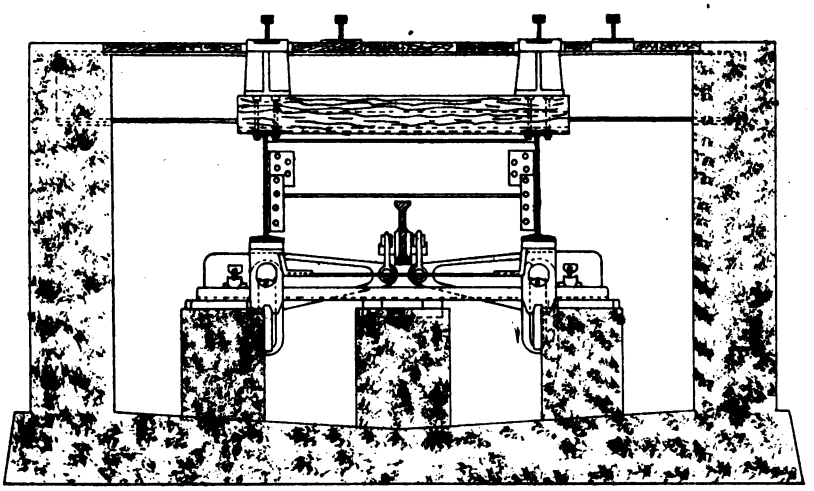


Fig. 64.—Pit Walls for Milder Climates.

In commenting on these specifications, which certainly tend toward good practice, the first criticism is of the blanket provision for foundation. Fig. 63 shows the end section of the pit called for. By referring to Fig. 64 the difference between these and a design for a point 400 miles farther south will be seen. Part of this is due to the necessity of protecting against frost

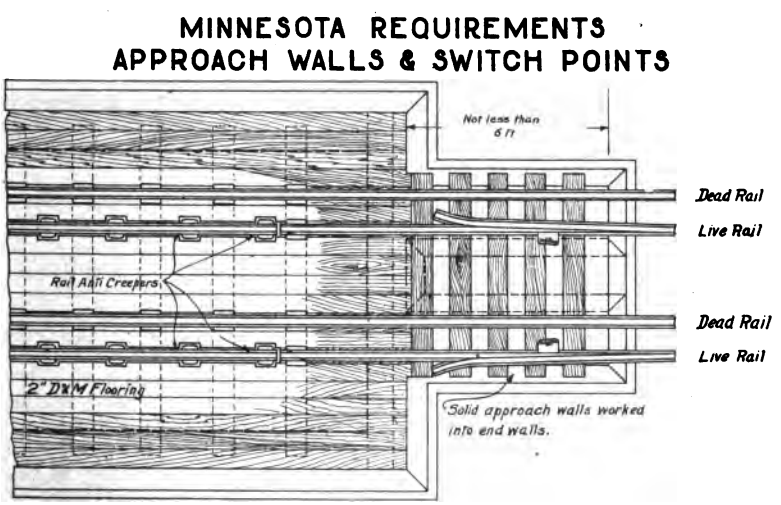


Fig. 65.

in Minnesota and part is the closer adherence to an economical design. Fig. 65 shows the method required in Minnesota of using switch points to prevent creeping of rails and the binding of the scale.

Fig. 66 shows the rain shield provided by these specifications, while Fig. 67 shows the rain shield adopted by the P. & L. E. and B. & O., and Fig. 68 shows one proposed by Col. A. S. Dodge of the Western Weighing Association. Fig. 68 is not so perfect a protection against rain as the others. Fig. 66 is objected to by some in the belief that it is possible for a lump of coal or other substance to become wedged between the guard and platform and affect the weighing. It is the most perfect protection against rain of any of the devices. Fig. 67 is better than Fig. 68; it is less effective than Fig. 66 as a rain guard, but it is less likely to become obstructed.

The proportioning of the I-beams and girders is more complicated than that of the foundations. It is customary to design the weigh bridge for a

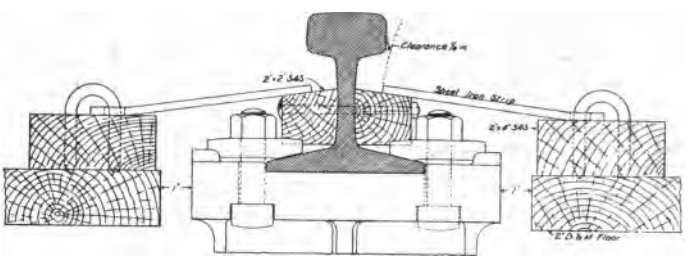


Fig. 66.—Rain Shield to Conform to Minnesota State Specifications

concentrated load equal to the heaviest to which it will be subjected. The wheel loading as shown in Fig. 39, with the axle load of the heaviest car likely to come on the scale, may usually be used. The I-beams or box girders used to sustain the deck should be computed for the live load of the heaviest engine on the road, probably the same loading as is used for bridges. With a 10-ft. pit, the distance from the center of the rail to the nearest wall will be 16 in. at the right wall and 4 ft. 4½ in. at the left wall. Of course these distances change with any increase of pit width. An I-beam should be embedded in the concrete to support the ends of these girders.

While the size of pit required above may appear to be unduly large, the present tendency is to use large pits. When the committee gathered its statistics in 1912 only seven roads reported a pit approaching the size given. Since that date we have reports from 26 other roads adopting pits of this size and also adopting a rigid deck.

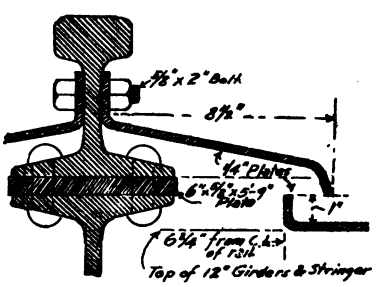


Fig. 67.—Rain Shield, P. & L. E. R. R. Track Scales.

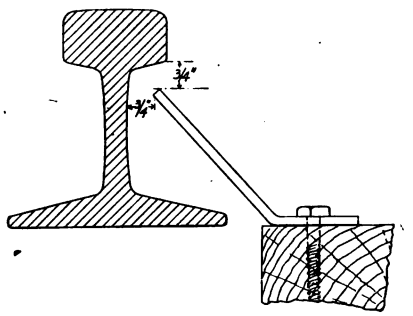


Fig. 68.—Another Rain Shield.

The main reason leading to the adoption of this type of pit, with its greatly increased expense, is the ease with which it can be examined. If no lights have been installed in the pit, it is possible to take a torch and thoroughly examine all parts of the scale mechanism and clean it.

Mr. Romig, in the report previously quoted from, writes of the installations:

"The general installation has as much to do with accurate scales as any other point we might bring up. In designing an installation care should be taken to provide access to all parts of the scale in order that they may be inspected easily. There is no reason why scales should not be installed so that any ordinary mechanic or weighmaster can inspect them. But to inspect many scales now in use it is necessary to put the scale out of commission, jack up the scale platform, swing levers from between the yokes, drive pivots from the machine, etc.

"Owing to the inaccessibility of the old style of scales, many loops, knife edges and bearings are filled with rust and dirt, causing the scale to weigh inaccurately, and work sluggishly and hard, so that the poise may be moved on the beam a distance representing 150 to 500 lb. and yet show an even balance. The latest design of scale is of such construction that an ordinary workman can inspect it, clean the bearings and oil the scale parts."

To see the force of Mr. Romig's remarks, compare Fig. 14 with Figs. 63 and 64.

The ventilation of the scale pit may be by a shaft or by any means which will ventilate without permitting the wind to blow directly on the scale parts. The best method of heating the pit is by steam coils. Where steam is not available, the space under the scale house might be excavated and a stove placed to heat both the scale parts and scale house. The deck should be made as nearly watertight as possible. Most installations are decked with plank from 2 to 6 in. thick. Two use steel, and we have been told of reinforced concrete floors. Where very thick planking is used, it is economical to have the planks grooved on both edges and make the tongue of a separate piece.

The installation of the scale is of special importance, and a scale that is not properly installed will not give accurate weights, however well it may be built.

MAINTENANCE.

In reference to the maintenance of track scales, the American Railway Association recommends as follows: that extensive repairs should be made in shops (and the same applies to the sharpening of knife edges); that scale parts be cleaned twice a month, and oftener if liable to become clogged with ice or dirt; that rust preventatives be applied to bearings in a way not to interfere with the working of the scale; that the weighmaster familiarize himself with the construction of scales and make inspections at frequent intervals to be sure that the scale is in working condition. Persons appointed to inspect and clean scales should be properly instructed, and if possible should be present when the scales are tested by the scale inspector.

The everyday problem of the track scales, and the one that most interests the members of this association, is that of maintenance. While the bridge and building men usually put in the concrete foundation, lay the deck, build the scale house, and furnish a goodly share of the muscle used in the installation, they thereafter figure only in assisting to remedy the ills of the scale. In this work they must use a large measure of good sense. The difficulty in remedying the ills of man is in diagnosing them. It is much the same with the track scale.

In an article in the "Railway Age Gazette" of March 17, 1911, describing the track scales of the Pennsylvania R. R., occurs this paragraph:

"The increase of the weight of the rolling stock in the last few years has rendered many track scales incapable of sustaining the heavier loads with-

out serious deflection of the members. Of course scales are not expected to weigh locomotives daily, but the travel of engines over the scale must be safe. Failure of the foundation or supporting structure, which in all cases bears a fixed relation to the support of the dead rail, would be serious. During the travel of a heavily loaded steel car over the scale it imposes a high stress successively on all the scale members. It is by free and unimpaired motion that a lever or any series of levers can fulfill their given functions. The magnitude of frictional effort increases in motion, and where the greatest arc of motion is performed the greatest care must be exercised to obtain the least friction. But, at the same time, friction increases with pressure, manifesting itself when the scale is loaded to its capacity by the prevailing sensitiveness. Where serious deflection occurs, as in weak scales, it increases the errors irregularly with the velocity at which the load may be applied to the scale platform."

This very nearly covers the case for maintenance. We must make such repairs and betterments as will keep down friction, reduce (and if possible eliminate) deflection in scale bridge and levers, and keep all foreign substances out of the scale pit.

Discussing the weakness of the old style of timber girder, Mr. Romig writes:

"It is very hard to secure timber that has not been bled and wind-shaken, no matter how careful the inspector may be in the field or woods inspecting the timber. We find about 50 per cent of the timber being used has been bled or wind shaken, and if there is one stick of this kind of timber placed in a scale it practically ruins all the balance. Timber is found to be in spots hard, harder and hardest, consequently various parts of scale irons are placed on timbers of varying density. Those parts resting on the softest spots settle into the timber very rapidly, thereby throwing the scale out of alinement. The scale that is not in perfect alinement cannot be made to weigh accurately various loads varying from the maximum to minimum. They can be set under this condition to weigh accurately only within a very small range of one specified amount. Due to the general make up of track scales, springing in timbers causes various errors, according to the dullness and direction of wear of the knife edges. Platform girders or the heavy timbers 12 x 18 in. spring down very perceptibly between the scale sections as the heavy cars pass over them."

Some of the most common troubles which cause a scale to weigh inaccurately are named below:

1. Troubles due to carelessness of weighmaster:
   Improper balance.
   Scale out of balance.
   Another car partly on scale.

2. Troubles due to weakness of scale:
   Deflection of scale bridge.
   Deflection of levers.

3. General troubles:
   Deck binding.
   Rails binding.
   Broken castings.
   Broken bearings.
   Dull bearings.
   Bearing feet resting on angle irons.
   Insufficient clearance between bearing feet and scale timbers.
   Levers out of line.
   Fifth lever out of line.
   Main lever loose.
   Foreign matter in friction with levers or scale parts.

The first named are out of our jurisdiction, but are troubles which often call an inspector to a scale. A common cause of improper balance is the weighmaster putting his free hand on the scale beam to steady it and bring it more quickly to a rest. One pound pressure on the beam may mean 10,800 lb. on the platform. It has been observed where a weighman had this habit that he has caused an error of 1400 lb. in weight of a car, and it is always too light.

The scale may be out of balance from losing lead from the poise or counterpoise, or from the improper placing of the latter. The last of the three conditions usually occurs where the weighman is a junior clerk, the switching crew in a hurry and harried, and disposed to take it out on the weighman. He is being cursed for slowness and gets a weight somehow to escape more abuse. In some cases, errors in weights may require the inspector to make several trips to a scale which is in good order, the errors being due to one of the above causes. He can detect and correct the second, but the others require detective effort.

Those troubles due to a scale of insufficient strength are subject to but small chance of remedies at our hands. Where it is a weak scale bridge (to determine which directions are given under the head of Adjusting), it may be feasible to strengthen it. This is easier with the old style wooden girder than it will be with the steel work now sometimes being used. Where two timber stringers form each side of the scale bridge, it is comparatively easy to use a truss rod between them, much as truss rods are used under wooden freight cars. If there is space on the sides, this plan can be used also with a single 12 x 18 in. stringer. Or a plate of steel can be bolted to the side of the stick, covering from two-thirds to all of the length. Care should be exercised to get the right size of plate, so that the deflection of the timber and plate will be equal. Rules for this can be found in any work describing the flitch girder. It may be possible to gain the desired strength by replacing the 12 x 18 in. stick with two 8 x 18 in. sticks.

The weak lever is not susceptible to cure at our hands. It may be accompanied by the weak girder. In such a case the deflections may be reduced somewhat by strengthening the girder so as to reduce the springing, and by having the cars handled carefully so as to reduce the jars on the scale. It is fortunate that most of our weak scales have cast iron levers, in which the deflection before rupture is quite small.

In the old type of scales, the deck is supported from the scale levers, and yielding of their foundations or at the bearings (from the cause named by Mr. Romig) may cause the deck to bind. When this trouble occurs, or when the levers are out of line or the main lever is loose, it is well to overhaul the scale and strengthen the foundations. It may be that it needs only the renewal of a rotting timber or cutting off a rotten pile and re-capping it. The mudsills under the framing may need to be renewed or rebedded, or to have their number increased. It may be possible to check settling by increasing the spread of the foundations and so reducing the load per square foot as to keep within the bearing power of the soil.

In connection with the causes of inaccuracy in scales, a report of the Railway and Warehouse Commission of Minnesota shows that out of 310 track scale inspections, in 158 cases the scales weighed the 100,000-lb. test car correctly: in 26 cases it was weighed too heavy, and in 126 cases it was weighed too light. The causes enumerated for the incorrect results are as follows:

Working parts out of level,	89
Binding,	59
Poor foundation,	54
Rusty and dirty pivots and loops,	25
Improperly built,	22
Working parts frozen up,	14
Shifted leverage,	13
Broken parts,	10

Dust laden poise, ... 4
Worn pivots, ... 3
False balance, ... 2

These inspections show the necessity of strong construction of the scales, good installation, proper drainage, ample facilities for ready inspection, and the making of regular daily inspections by the weighman. In many of the scales, several of the causes noted combined in producing the erroneous records, but it is to be noted that in the 310 inspections the first three defects were found 202 times, while all the others combined were found only 93 times. This indicates that improved foundations and better bearing of scale parts on the timbers would have avoided two-thirds of the defects. We might properly go further and include the 22 cases of "improperly built" scales, and thus lay three-fourths of the troubles to this group of defects. With the better class of the older scales it is probable that it would pay to renew the timber foundation with concrete and the timber girder with steel, the work being done in such a way as to permit of installing a higher class of scale in the future.

It is worth noting that one track scale that first weighed the test car 50 lb. light, weighed it correctly after the dust was brushed off the poise. One scale in service gave the weight of the car as 93,000 lb., due to a broken part. Two scales gave the weight of the car. as 71,000 lb. and 85,400 lb., due to the fifth lever being frozen up. These two cases illustrate the importance of draining the pit. Assuming that three cars were weighed while the scale was in this condition, at 90c per cwt. there is a loss of $800 in one case and $250 in the other case.

As to rules for the use of scales, we have selected those of the Missouri Pacific as covering the ground, and they will be found in Appendix D. The Illinois Central has in the scale house or on the beam box a card with the following rules:

1. Engines shall not run over track scales, nor shall switching be done over same.
2. Scale switches shall at all times be set for the dead rail tracks unless the scale is in actual use.
3. Engines shall not stand over the track scales, nor shall sand or injectors be used while engines are passing over dead rail of scale track.
4. Weights shall not be taken while cars are in motion except on automatic scales.
5. On automatic scales, cars must move over the scale slowly enough to allow the type wheel to stand still when the hammer prints; the speed should not exceed 3 to 4 cars per minute. Weighmaster must insist on this. Cars too short for this scale must be uncoupled to weigh correctly.
6. The agent, or person in charge of the scales, shall see that the scale beam is kept clean, so that the figures may be plainly seen.
7. Scales shall be properly balanced before cars are placed upon the scale for the purpose of being weighed.
8. When scales are discovered to be out of order, the superintendent of the division, the supervisor of scales at Centralia, and the general superintendent should be notified at once by wire.
9. Each track scale shall be specially tested once each month by reweighing five or more heavily loaded cars consisting of shipments other than coal which have been weighed upon track scales at other points.
10. A record of such test weights shall be made in scale book, Form 728, showing date of waybill and number, car number and initials; and a statement showing the same information shall be mailed to the division superintendent, and a copy to the supervisor of scales at Centralia, Ill.
11. A record of all cars weighed on each track scale shall be kept in scale book, Form 728.

Other rules which are issued by some lines are to the following effect: that when scale parts are frozen, salt must not be used to thaw them out, but artificial heat must be used where practicable; that cars must be prop-

erly spaced, and must be run beyond the scale a sufficient distance before stopping to prevent cars coming together on the scale; that when it is necessary to apply brakes to secure proper speed or spacing of cars, they must be applied some distance from the scale, and released while the car is passing over it; that cars must not be stopped violently on the scales by application of brakes or blocks under the wheels. It is common to rule that in bumping cars off the scales, the speed of the bumping car must not exceed 3 ft. per second at time of impact. It is usual to limit the speed of cars when passing over the scale to twice that speed.

These rules do not belong to the bridge and building department, but are inserted here for the reason of their vital connection with maintenance of the scales. Without the coöperation of the division superintendent, trainmaster and agent, and we might say the yardmaster, our efforts to maintain scales in operating condition will be of little effect. If the rules are understood and enforced good results will follow, and we should impress their importance upon those who can enforce them. The yard crew often look on weighing as a nuisance, and regard the weighman as stupid. It is necessary to show them clearly and forcibly the necessity for accurate work, and then to discipline any offenders against the rules. Before this can be secured the trainmaster and superintendent must be made to see how necessary these rules are to correct weighing, and what losses the company sustains when they are not observed.

We are indebted to Mr. Fred Cruikshank for the following summary on scale maintenance:

"In preparing a discussion on the matter of scale maintenance, we will consider scales having entire or partial wood construction as those most subject to defects which may affect accurate weighing, and will deal with the more common defects or ailments, with suggestions for their remedies in scales of this character or type. Before discussing any of the defects we will consider the foundation briefly, as the most essential part of the scale installation.

Great care should be exercised in constructing the foundation of a track scale; first, to get some substantial material on which to build the foundation, and second, to see that all levels are accurately taken and all surfaces on which scale parts or stands are to rest are properly surfaced to give full and equal bearing. It is most important to have the concrete or masonry work so constructed that it will not settle or crush under load. With these suggestions carried out we have eliminated one great source for defects, and have only those caused from ordinary usage and deterioration to deal with.

The more common defects and ailments found in general observations of the track scale and suggestions for their remedy are noted below:

1. Binding of Deck:—This defect may be caused by not having allowed sufficient clearance between the stationary parts and movable portion of the scale platform at time of installation; by coping timbers not being properly anchored to foundation walls, allowing them to be forced in toward the scale platform by frost or other influences; by scale platform not being sufficiently checked, allowing platform to shift on its bearings to the extent of binding against stationary parts; and by timbers under bearing stands decaying or crushing, throwing platform out of level. At the time of installation the scale platform should be cut to give at least ½-in. clearance around the edge and around pedestals (if there are any) to support the dead rails. All openings should be cut with a bevel edge on the under side of the decking to prevent obstructions from becoming wedged in the openings.

The coping timbers should be anchored to the foundation walls to prevent shifting, and where the dead rail is laid on the outside of the coping it is sometimes necessary to anchor this by anchor rods secured to posts set in the ground outside the coping wall.

The platform check rods should be so adjusted as to allow from ⅛ to ¼ in. swing to the platform. If difficulty is experienced in holding platform to proper place by the system generally used, the checks may have one end

anchored to the foundation wall and the other to scale platform girders or stringers. Care must be exercised to see that the ends attached to the wall are slightly lower than the ends attached to the scale. If the platform binds on account of the bearing supports being out of level, it is necessary to make substantial repairs by renewing the defective parts of the foundation.

2. Binding of Rails:—This is a very common trouble, and one for which there is little excuse, as it is generally caused by one of two things: 1, rails not properly anchored on scale platforms; 2, approach rails not properly anchored to prevent creeping. The rails on the scale platform should be secured in place by bolts passing through the rail base and down through the platform girders or stringers. Where these rails are laid and spiked on ties which are anchored to girders, or where they are spiked to deck planking, the base of rail should be slotted for the spikes at frequent intervals.

It is almost impossible to maintain a proper clearance between scale rails and approach rails on account of expansion and contraction of approach rails, unless some substantial means of anchoring these rails is provided. While some success has been experienced with certain anti-creepers, we do not believe they are a general success in such cases.

Probably the most efficient and reliable means of securing the approach rails to a proper position and maintaining this position is by the use of switch points adjacent to the scale. The points are placed with the butt ends toward the scale platform, and have the base slotted for spikes. The stock rail is then bent outward and cut at the proper distance from the scale, and the switch points are securely spiked against this rail. Any creeping due to expansion, contraction or other cause is taken care of by the points, so that the spacing at the ends of the scale can be maintained. This space should not exceed ½ in.

3. Binding Between Yoke and Bearing Plates or Scale Timbers:—This may be caused by not having originally made sufficient clearance between yoke and platform timbers, by platform timbers spreading slightly at the top or bottom, or by the platform shifting longitudinally on its bearings. This defect can be remedied by giving proper original clearance, and by tying the platform timbers securely at top and bottom to prevent spreading.

The binding between the yoke and bearing plates may be caused by platform timbers spreading at the bottom, or by stretching of the links supporting the main levers on which the plates rest, allowing the plates to drop down so they will strike against the expanded portion of the base of the yokes. The remedy for this defect is as given above, to prevent the timbers from spreading and to keep the links the proper length. If scale foundation or bearing stands are out of level, it will cause the platform to swing toward the low side and cause binding against yokes. This can only be remedied by leveling up the stands.

4. Bearing Feet or Plates Resting on or Coming in Contact With Angle Irons on Frames:—This is another very prevalent trouble with timber scales, and is generally caused by the bearing feet or plates crushing in the platform girders or stringers on the outer or back side, causing the nose of plates or bearing feet (to which are secured the plate tie bars) to slip downward and come in contact with the angle irons on the cross section frames. This condition might be caused also by the links supporting the main levers being too long, or by the knife pivots being badly worn, but a scale in this condition would be unfit for service.

For a remedy and a prevention of the defects caused by plates crushing into platform timbers, it is suggested that when first placed on the platform girders or stringers the front or inside edge of the plates or bearing feet should be dapped into the timber about ½ to ¾ in. This will tip the nose of the plate upward slightly and allow for considerable crushing in at the rear edge of the plate before the nose of plates will strike the angle irons. Where soft material is used for platform stringers it is often desirable to fit hardwood blocks or steel plates under the bearing feet or plates. Of course the greater the bearing surface the less is the liability to crush the timbers.

5. Levers Getting out of Line and Level:—About the only cause for

this is for the foundation to give way or timbers underneath the stands to become rotten or crushed. The only remedy is to ascertain the cause of the trouble, whether in timbers or foundation, and correct it by replacing inferior material. We would not recommend using light shims of any kind for leveling up any scale lever or bearing (unless in the nature of steel plates in a steel constructed scale), as it would be only a temporary relief and not a remedy.

In scales having five or more sections where the 1 to 1 transmission or connecting lever is used to connect the sections, it is very common to find the extension levers out of line and level, due to the transmission or connecting lever which has an up pull on the fulcrum loop being out of level on account of not being properly or securely anchored. Too much care cannot be exercised in getting proper anchorage for this lever, and even with the best effort in this respect we find it almost impossible to keep this lever in proper position without frequent attention. The fifth lever does not frequently get out of line or level except by generally very bad condition of timbers supporting it or by varying length of the steelyard rod. If the fulcrum stand of this lever is securely anchored in proper position the lever can be very easily leveled by adjusting the turnbuckle in the steelyard rod.

6. Dull Bearings and Broken Castings:—There are two causes for dull bearings: wear and corrosion; and it is a question which of these is the greater factor. The greatest wear on pivots naturally comes on the main lever knife pivots, as this receives the first impact from the weight applied, and we invariably find that the pivots in the levers constituting the end sections of the scale show the most wear. This is due to the excessive impact received from the cars rolling over the open joint (often with a slight drop), which delivers to the scale instantly the full load on each pair of wheels. This condition can be remedied, if not entirely eliminated, by the use of a buffer rail, or a flexible easer rail to carry the wheels over the joint without impact.

The protection of dull knife edges from corrosion seems without solution, but a number of experiments are being conducted. However, if scale pits or vaults are properly drained and scales are frequently cleaned and irons painted, the trouble will be reduced to some extent.

We do not advocate using any kind of liquid oil on pivots or bearings, as this only tends to collect dirt, which is probably as injurious as corrosion. Some experiments are being made with cup grease or hard oil, which is applied by filling it into all loop bearings around the pivots. We are unable at present to report on the success of the experiment.

Breakage of scale castings and bearings is caused generally by the parts being subjected to strain beyond their intended capacity. As a remedy, we suggest that scales be equipped with dead rails, and nothing but cars to be weighed be allowed to pass over the scales. All engines or other equipment having upon any axle or truck a concentrated weight greater than the actual capacity of the scale parts constituting a section, should not be allowed to pass over the scale.

In conclusion, we wish to condemn the practice of adjusting nose irons on scale levers to overcome all irregularities in the weights. Nose iron adjustment should not be made until it is determined beyond question of doubt that other influences are not in any way affecting the weight.

As a final suggestion, or recommendation, it is earnestly recommended that in all future scale construction (whether for the newer types or the older standard type) the use of timber be eliminated, excent for the tie deck or other platform covering. In this way the majority of troubles above discussed will be almost entirely eliminated."

The committee thanks Mr. Cruikshank for this description of maintenance of track scales. It must not be forgotten, however, that it is just as necessary for the steel and concrete (as well as the wood) to be of ample strength. An experience last winter on a road having a well organized engineering department showed that this caution is not now out of place. A southern road had been considering a 50-ft. five-section scale, and intended

to use a 16 in. I-beam under each rail for a weigh bridge. These were of course to be braced. The Southern Weighing and Inspection Bureau talked them out of a five-section scale, and they had decided on a 50-ft., four-section scale (style Fig. 35), with a weigh bridge made of two 18-in. 65-lb. I-beams. If they used less than two 100-lb. 24-in. I-beams the resultant work of the scale is readily foreseen. It can not be too strongly impressed on users that scales will not remain accurate unless the weigh bridge is of such strength that there is no appreciable spring or deflection, the levers strong beyond deflection, and the knife edges and pivots ample for their purpose.

INSPECTION AND TESTING.

An important consideration is the manner of testing the scales. Mr. Motchman and many others say that a 100-ton scale should be tested with a test car weighing 25 tons. But coal cars of 100,000 lb. capacity weigh light from 37,000 to 45,000 lb.; the rules permit a load of 10 per cent above the stenciled capacity, and the loaded car weighs from 147,000 to 155,000 lb. The axle load then may be from 35,750 to 38,750 lb., and the load brought on a section approximates 100,000 lb. We buy what purports to be a 100-ton scale which will in actual service be overloaded fully 80 per cent by a 75-ton load.

The scale manufacturers' method of rating leads to strange results. One salesman claimed that a six-section scale was a 150-ton scale, on the ground that as a four-section scale having the same size of levers and length of knife edge was a 100-ton scale, the scale having the two additional sections must be a 150-ton scale. If a four-section scale should be tested to one fourth its capacity, there is no reason why a six-section scale should not be tested to one sixth its capacity. When we reach a rating that will call for the construction of a 100-ton scale which will be proportioned to weigh 100 tons as usually loaded in present equipment we will get away from many confusing features.

Another trouble in testing comes from the fact that a scale may be in bad shape from some of the defects discussed elsewhere, and when adjusted by the scale inspector it will weigh the test car correctly but will not weigh correctly a loaded coal car of three times that weight.

It is no part of the inspection to determine if the scale is strong enough for the service required of it. The scale may be inadequate, the scale bridge weak, and the pit badly drained and difficult of access. But the inspection and the tests must be so conducted as to get the best possible service from the scale.

It must be recognized that it is highly essential that the scale machanism, which serves to measure and determine in a large degree the revenue of the railroad, should be inspected regularly to ensure that it is kept in condition to do its work properly and fairly. For the best results the mechanism should be inspected each day before being used. If there are two shifts of weighmen, each man, before going on duty, should go under the scale and examine all knife edges and bearings, and all points where binding may occur.

As to how frequently the scale inspector should visit the scale and make an examination and test, this may be said to depend on the scale itself. The Glassport scale of the P. & L. E., with its excellent design and installation and double daily inspection by weighmen, might have gone five years without other inspection and test if we judge by the results of tests. Some companies with very good installations have found it to their interest to put the test car on the track scales daily. It is perhaps safe to say that a track scale subjected to spot weighing should be inspected at least once a month by an expert, and it might be well to test it at the same time.

The answer to our queries as to how often scales were inspected and tested brought out the following information:

	Inspected	Tested
Weekly,	6	3
Bi-weekly,	5	2
Monthly,	23	10
Bi-monthly,	15	16
Quarterly,	22	25
Three times a year,	0	7
Semi-annually,	7	8
Annually,	3	4
Irregularly,	4	7

Testing seems to be quite general, contrary to some published statements, as but 28 roads (having a total of only 175,000 freight cars) report having no test car, while 57 roads (having 1,683,000 freight cars) report having such cars. Many of the roads which have no test car report having their scales tested with a test car of some weighing association or connecting road.

As showing the causes which contribute to the inaccuracy of track scales, the following items are taken from the report of the Railroad and Warehouse Commission of Minnesota for the year ending November, 1912. This covers all track scales outside of Minneapolis and Duluth, whether owned by railroads or shippers. Of the 361 tests, 44 were for the purpose of rating new scales or scales that had been repaired. Eliminating these, the figures are as shown in the last two columns:

	Total of tests		Exclusive of rating tests	
No. of scales tested,	205	....	...	....
No. of tests made	361	....	317	....
Tests giving correct weight,	158	43.8%	158	50.0%
Tests giving underweight,	165	46.0%	132	41.6%
Tests giving overweight,	38	10.5%	27	8.5%

Analyzing the 27 tests which gave excessive weights, we get the following causes: working parts out of level, 17; shifted leverage, 5; faulty foundations, 3; broken parts, 2. Analyzing the figures further, we find that the average overweight or excess was 400 lb., and that the average underweight or deficiency was 960 lb. Of the erroneous weights, 92 per cent were underweight and 8 per cent overweight. This is a matter for serious consideration. If each scale weighs the same volume, 50 per cent of the weights will be correct, 46 per cent will be too low and 4 per cent will be too high.

This would indicate large losses to the railroad companies from their track scales being out of condition. Lack of knowledge of the conditions surrounding each scale prevents the drawing of definite conclusions, but it seems that many of the scales giving unsatisfactory results are owned by shippers, and others by roads which make few tests. The commission makes tests once or twice a year. One of the causes given for incorrect work of scales is "working parts frozen up," and where scale pits are in such condition that this is possible the weights given by these scales will be of no value.

The methods of testing on the Santa Fe are given by Mr. F. C. Maegley as follows:

"We have two steel cars of short wheel base (6 ft.) which weigh 31,500 lb. each. Each car is in charge of a scale expert, and with the two we aim to give every scale on the system a test about three times a year. In addition to this, the district inspectors make tests with loaded cars according to necessity, about once every one or two months. The agent at each track-scale station is required to make a loaded-car test once each week, reporting the result to the district scale inspector."

Mr. R. W. Romig, who was a scale inspector for many years over a wide range of territory, writes as follows on the subject of inspection.

"When the scale inspector arrives there should be sufficient help at hand to set the car on and off the scale platform. With present installations, the rails to and from the scales are often higher or lower than the rails of the scale platform, so that two men cannot shift the car. Owing to infrequent tests and inspections, the scale inspector finds it necessary to make adjustments, and where the car is not moved on and off he has no means of knowing what is the dead balance.

A test car should be carried on two axles, with a wheelbase not over 7½ ft., as this is the maximum for freight-car trucks. The test car should weigh half as much as the maximum load. Care should be taken in the general construction to guard against wind pressure. The car should weigh 35,000 lb. and be equipped with 35,000 lb. of standard test weights, making the total weight 70,000 lb. Each morning, before starting the day's weighing, it is a good practice for the weighmaster to see that his scales are properly balanced, and then weigh one car at least three times to see that the scales will give the same result each time.

When dirt is allowed to accumulate in scale pits, it holds moisture which settles on the scale bearings; these then gather dust and matter floating in the air, which may contain chemicals that will attack the steel parts. The sulphur gases, especially from soft coal, eat up the steel parts very rapidly, and the deck should be of such construction as to keep out these injurious elements as much as possible. Pits should be wide and deep enough to allow easy access to all parts that they may be cleaned and oiled. Ordinarily, the cleaning and oiling are only necessary about every two weeks, but near the coast more frequent inspections may be necessary."

The proper weight of a test car for track scales seems an open question. All scale men seem to advise a car weighing one-fourth the capacity of the scale. As present equipment imposes a load equal to half the weight of car and load on each section in the process of weighing, and on the central sections in passing cars over the scale a load equal to two-thirds the car and load, it would seem the test car should approach one of these maximum amounts. This would make it from 75,000 to 106,000 lb. Would it not be a good plan to use a car with a wheelbase of 5 ft. 8 in., weighing 60,000 lb. and having pockets for holding rigidly 20,000 lb. of test weights with which it is equipped? This would give a car which would test each section of the scale to about its service load in weighing. It would also permit the inspector to test his car in case of accident to it without access to the master scale.

The plan would be a little tedious, but by placing his test weights on the scale, setting the beam to that balance, removing the weights and placing some sort of available scrap or other material until the scale balanced, he would have that weight correct. Placing his 20,000 lb. of test weights back on the scale and bringing it to a balance, removing the test weights and placing another lot of scrap on the scale, he would have the scale weighted to 40,000 lb. Then adding the test weights, he could balance the scale and know it was 60,000 lb., and could set his test car on the scale, adjust it to this weight and replace his test weights and know his car was the correct weight. This, of course would have to be done only when the car had met with an accident, or after it had been a considerable time on the road. The question of scale testing and test cars is likely to receive much attention in the near future, and we quote the following from a bulletin of the Bureau of Standards (U. S. Department of Commerce), Washington, D. C., in regard to an appropriation for the use of this Bureau in testing large scales and weighing machines:

"The appropriation will be used to provide and make available an equipment which will serve the following purposes: 1, To provide means for testing scales and determining their accuracy; 2, To provide official standards (heretofore lacking) which will be used in standardizing the master weights and master scales and equipment used by weights and measures officials, railroads, corporations, etc., in testing scales and weighing apparatus; 3,

Methods of tests will be studied, for determining what tests are adequate for insuring reliable adjustments in scales; 4, The mechanism of scales will be studied to determine the common faults and specify remedies. Scales have received little attention from an engineering standpoint and many of them are inadequate to perform the work intended. Scale capacities are loosely defined, with the result that stated capacity in many scales is only nominal and forms no index as to what could be expected of the scale. A study will be made of these features with the object of reducing the subject to a satisfactory engineering basis; 5, Weighing methods and practices and organizations will be studied for determining the most efficient means for realizing correct weights.

"A car will be provided for housing and transporting the equipment proper. The main items of equipment will consist of eight 10,000-lb. weights, four 2,500-lb. weights, and 10,000 lb. of 50-lb. weights, together with smaller weights making a total of over 100,000 lb. of test weights. Auxiliary equipment will be provided for handling the weights, consisting of a motor-driven truck for holding the weights during test and carrying them from point to point on the platform of the scale; a crane for handling the weights and truck, and storing them for transportation; and a gasoline engine and 10 k. w. generator for supplying power. There will be also a storage battery, lights, office space, and auxiliary equipment for making the study on the action of the mechanical parts of the scales."

While this promises a thorough investigation and an authoritative determination of many disputed points concerning track scales, it is a hazard to guess how far it will affect present methods of testing. A few instances of test cars in use are given.

Fig. 69 shows the test car which has been in use by the Minnesota Railroad and Warehouse Commission for a number of years. It was altered from a steel ore car. The commission has found one car inadequate for the service, and has ordered two new ones. Fig. 70 shows the new car.

This car has a wheel base of 20 ft. and each truck has a wheel base of 5 ft. 4 in. It is equipped with air brakes, automatic couplers, draft gear and safety appliances. It is sheathed with iron 3-12 in. thick. The car and dead filler weigh 88,000 lb., and the car is supplied with 12,000 lb. of test weights which are removable for other use. This car does not comply with the requirements of the American Railway Association, and it is unlikely that any railroad commission will ever be able to devise a car which will do so. The great mileage which such a car must make necessitates one which can be handled in an ordinary freight train. Wear on brake shoes and boxes, changes due to repacking, etc., lead to numerous small errors in this type of car. The work undertaken by the Bureau of Standards may lead to some other method.

Some roads convert an old tender into a test car, and the short wheelbase makes this easily adaptable to the purpose. The Duluth, Missabe & Northern uses an old ore car. This is shown in Fig. 71.

This road has not a great mileage, but it has a very heavy ore traffic and its cars are very largely of one type. The test car is practically the standard ore car, but provided with roof and loaded to 127,400 lb. In the main receiving yard at Proctor are two track scales on which the ore cars are weighed. Every morning during the shipping season these scales are tested with the car up to nearly the average load to be weighed.

Fig. 72 shows the test car of the Southern Pacific which is very similar to those used on many other lines. Every effort is made to remove tendency to pick up material which would tend to change the weight of the car. It has no brakes. It weighs 30,000 lb.

Fig. 73 shows the test car of the Illinois Central, which weighs 100,000 lb. It is subject to the same criticism as to brakes, etc., as the Minnesota car.

Fig. 74 shows the Y-B type of test car used on the Pennsylvania, which is described in Mr. Epright's paper, Appendix B to this report. It is very similar to those in use on several eastern railroads.

Fig. 69.—Scale Test Car Moo, State of Minnesota.

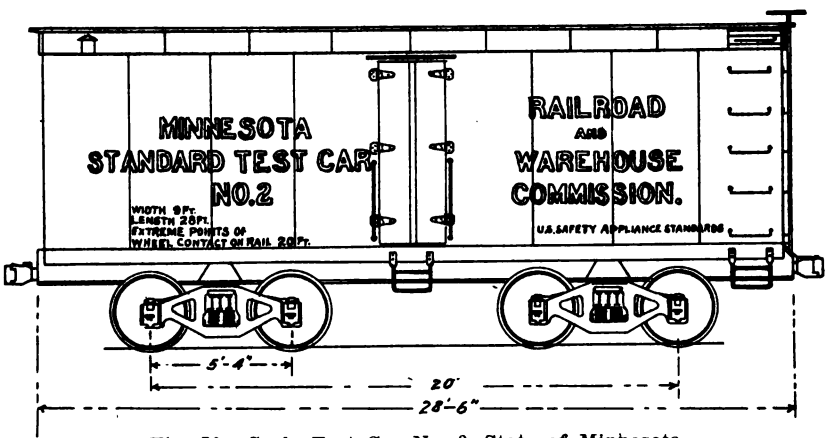


Fig. 70.—Scale Test Car No. 2, State of Minhesota.

Fig. 71.—Scale Test Car, D. M. & N. Ry.

The tests of track scales may be described as of three types. First, a daily test should be made by the weighmaster. If it be a scale used for manual weighing, he should each morning (before doing any weighing) examine the scale rails or platform to see that no part is binding. If the pit is accessible he should make an examination to see that no parts are binding or in any way interfered with, but are free to act. He should then test the balance, and at least once a week should test the scale with a loaded car of known weight and loaded with some material which does not change its weight by losing or absorbing moisture, as does coal. At this test the sensitiveness of the scale as to both beam and platform should be made.

Second: The beam test can be made by bringing the scale to a balance by moving the poise up to a balance from a lower weight, and then moving it to a higher weight, and bringing down to a balance and noting if they agree.

Third: The platform test is made by having a known weight added after the scale is brought to a balance with the car on it. This may be done by a man stepping on the rail. The scale should show this change with a measure of accuracy.

Report of this test should be entered in the scale book, where it becomes a part of the permanent record. It should state that the scale was balanced, how many pounds it took to change the balance in the platform test, the discrepancy (if any) in the beam test, and that there was no binding of the approach rails. If the scale is of an old type, the record should state that the platform was free from bind, clean of rubbish, snow and ice, etc. If the pit can be examined, the record should state whether the scale levers are free from friction in moving, and the pit free from water, ice or rubbish which might affect the action of the scale.

The weighman should be sufficiently familiar with the scale to detect and remedy minor troubles. In one case a scale carpenter spent two days

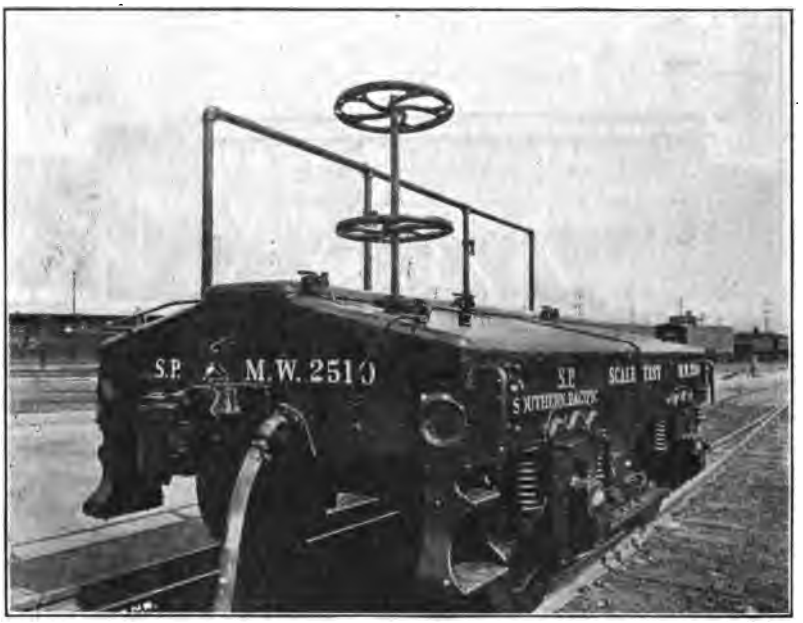


Fig. 72.—Scale Test Car, Southern Pacific Co. Wheel Base, 6 Ft. 4 In., Weight, 30,000 Lbs.

Fig. 73.—Scale Test Car, Illinois Central R. R.

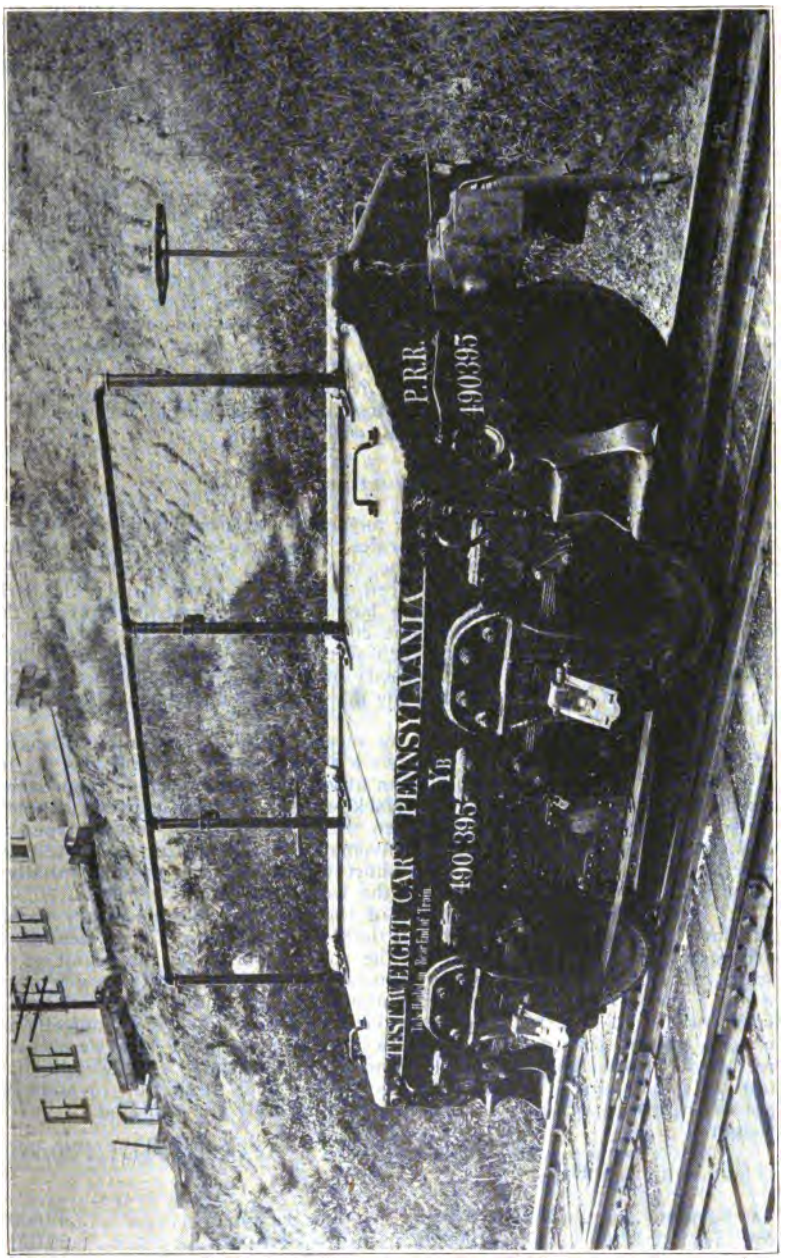


Fig. 74.—Test Car YB, Pennsylvania R. R.

going to and returning from a scale which was reported as being out of order, and found some mischievous person had driven a piece of a cane between the pit wall and the live platform.

The monthly or semi-monthly visit of the scaleman or scale carpenter should be covered by a more elaborate report than that of the weighman. It should give the location and general dimensions of the scale, and note the condition of pit, mechanism, platform, rails and approach. Also, whether the weighing rules are being observed, and what work was done on the scales at this visit.

The report of the inspector with the test car is still more elaborate. Besides noting the location it gives the date of test and the last previous test, make of scale, number of sections, length of scale, capacity, when installed, type of foundation, beam equipment, whether a dead rail is used, whether a beam box or scale house is fitted, and if this is kept locked. It should note also the condition of approach rails, platform, timbers, floor, knife edges, etc. It should show whether the pit is well drained, levers in proper level, beam quick or sluggish and how many pounds it takes to change the balance; what repairs are needed and whether the repairs recommended at the previous inspection have been made. Further, it should give in detail the result of each test made with the test car, giving the true weight of the car and the weight recorded on each section at each test.

ADJUSTING.

It has been impossible to secure any complete instructions as to the adjustment of the different types of scales. We have secured two articles on the adjustment of the Fairbanks type, one written in 1902 and one in 1906. As the last named appears to have been modified from the former, the earlier one is used below. The committee has altered the metric terms to their equivalents in feet and pounds. The committee wishes to dissent from the statement in the first clause that each section in a four-section scale should be tested to one fourth the rated capacity of the scale. This has been touched on under the head of capacity, and the tables Nos. 3 and 4 are referred to on this point.

By E. Motchman.—"The railway service requires continuously-accurate scales, and means to maintain them so with the least delay and loss of time. A track scale should be tested with an absolutely certain weight, approaching nearly the capacity of the scale. A track scale of 100 tons capacity should be tested with a weight of 25 tons, when the scale is a four-section type; this will aggregate its capacity. For convenience in transporting this test load may be in the shape of a car, with short wheelbase, built as substantially as the usual rolling stock to withstand the wear and tear of service.

"To establish the exact weight of the test car, it is necessary to have standard weights to the amount of half its capacity. These weights are arranged tightly in the interior of the car, and may be taken out to test scales of smaller capacity when required, or to obtain the weight of the whole. To do this, the test car is unloaded of its known contents, and the scale tested and adjusted to the standard weights. Then it is logically correct to assume that a scale which weighs 12½ tons of test weights correctly will also weigh a car of the same weight correctly. The weight of the test car is the sum of these. A test car filled with scrap iron or steel does not offer this opportunity to establish on any scale the standing of its own weight.

"A four-section scale tested with such a car of a weight of 50,000 lb. gives results as follows:

1st Section,	50,040 lb.	3rd Section,	49,800 lb.
2nd Section,	49,900 lb.	4th Section,	50,020 lb.

"On examination of the scale, it is found that all corrections must be made in the second and third series of levers, namely, the extensions and the

fifth lever, as these levers have movable knife-edges set in slides. In the correction, the connections should not be disturbed from the vertical lines and great changes in nose irons should be avoided.

"If 50,000 lb. is the neutral point, the first section (50,040 lb.) is a plus, and the second section (49,900 lb.) is a minus. To regulate the first section, the length of the end extension lever must be increased for the plus sign, and for the second section the length must be decreased; when the leverage is changed in this manner, the pressure also changes, and so gives means for correction. The amount of movement of the nose irons depends upon the length of the lever and the discrepancy in the weight. In this case there are three items known: length of the lever, weight of test car and discrepancy. The character of the wanting size is known to be plus for the first section and minus for the second section. Summarizing we have, weight of car 50,000 lb.; length of lever, 6 ft. 6 in.; discrepancy, plus 40 lb.

50,000 : 6.5 :: 40 : X
X equals 0.0052 ft. or 1-16 in.

"As the sign is plus, the lever must be increased by 1-16 in.

"For the second section, it is assumed the long arm of the lever is 5 ft. 5 in., or 5.4167 ft. It is also known this quantity will be less, and the proportion will be:

50,000 : 5.4167 :: 100 : X
X equals 0.0108334 ft., about ⅛ in.

"This being a minus quantity, the lever will be shortened by moving the nose iron closer to the stationary pivot. The nose iron at the other end of this lever must be moved an equal amount in the same direction, to the center of the lever, to maintain the combined function of this lever, not as a multiplying lever alone, but also as an even transmitter from the first section. It will be clear that the movement of the nose iron in the second section affects the pressure of the first section, and in some cases offers advantages by changing this even transmitter (to benefit the first section) into a minutely uneven lever.

"Should the movement of the nose irons affect the vertical connection, then another correction may be made in the short arm of this lever, but the direction of the movement is then in opposition to the longer distance between the knife edges. The second knife edge on which the main levers are attached can be set over (to increase the pressure) by filing or grinding an amount obtained by dividing the obtained movement of the nose iron by the real multiple of the lever, which is 8 1-3 in this scale. This gives a quotient of 0.0013 ft. or 1-64 in., or by proportion when the short arm measures 7 11-16 in., or 0.6406 ft.

49,900 : 50,000 :: 0.6406 : X
X equals .6419.
.6419 — .6406 = 0.0013, = 1-64 in.

"After this correction is made in all four sections, the scale is rebalanced and another test made. If all sections now show the same weight, but not 50,000 lb. (say 50,100 lb.), then the next correction may be made with the fifth lever, while the car is standing on the scale. This lever measures 9 ft., and the discrepancy is plus; the length of the lever must be increased. The proportion for this correction is:

50,000 : 9 :: 50,100 : X

X equals 9.018 ft., and the lever must be lengthened the difference, 0.018 ft., or 7-32 in. The nose iron is moved this distance outward, the scale rebalanced with the poise at zero, and the test car pushed on the scale should now indicate 50,000 lb., if the levers are not worn too badly.

"In repeated trials with the test car lies the best means to determine the fitness of the scale for future service, the sharpness of the knife-edges, the solidity of the structure and various sources of error. A defective scale will never show the same indicating values in succession with a heavy test car on short wheelbase. This test with such a car will locate the defective section, which cannot be done by the use of a freight car or a test car with a long wheelbase.

"Condensing this method of correction, let

L equal length of levers, 9 ft.
W equal weight of test car, 50,000 lb.
l equal length of corrected lever
w equal discrepancy of test car, 49,980 lb.
m equal movement of nose irons, L—l

Then first, l equals $\frac{w \times L}{W}$

And second, l equals $\frac{W \times L}{w}$

"These two formulas show at once the application. When an increase of length is necessary, the product of the lever and the larger weight is divided by the smaller weight, the quotient is the desired length.

"Substituting values,

l equals $\frac{49980 \times 9}{50{,}000}$ equals 8.9924 ft., which equals 8 ft. 11 29-32 ins.

"The movement of the nose iron on the fifth lever of given length by a test car of given weight, with an error within 20 lb., has been found to be 1-25 in., approximately by proportion. It follows that when the error is known, a correction ratio can be found from the weight of the test car, which applied to length of lever gives directly the movement of the nose iron.

"Assuming that a lever of the first degree (in perfect order) requires 800 lb. at one end to balance 16 lb. at the other, its long arm being 1.6667 ft. (1 ft. 8 in.) and its short arm 0.0339 ft. (13-32 in.). If by wear or other causes it requires 808 lb. to balance the 16 lb., then the error would be 8 in 800, and the correction ratio is the correct weight divided by the error (800 ÷ 8 = 100).

"The correction must shorten the long arm and lengthen the short arm to reëstablish the desired proportion. Dividing the long arm or the short arm by the correction ratio gives the required movement of the knife-edge. In this case, 1.6667 divided by 100 equals 0.0167 ft. (3-16 in.), and 0.0339 divided by 100 equals 0.0034 ft. (1-32 in.). This is a like shortening of the long arm or lengthening of the short arm. It is evident that by wear the short arm distance might change 1-32 in., but that it is not possible for the long arm to change its length 3-16 in.

"Applying this method to the third section of our track scale, the solution may be quickly obtained. The reading of the beam was 49,800 for the 50,000-lb. test car, giving an error of 200 lb. The correction ratio is 50,000 ÷ 200 = 250. Dividing this into the long arm of the lever (which is the same as the second section), 5.4167 ÷ 250 = 0.0217 ft. (17-64 in.).

"Finally, for the fourth section say, error = 20. Then 50,000 divided by 20 gives a correction ratio of 2.500. Length of lever is 6½ ft. This divided by 2,500 and taking the discrepancy as 20 equals 0.0026 ft., or 1-32 in., an amount only half as large as the first section, due to the proportionately smaller discrepancy.

"Of course this method assumes the understanding of the plus and minus valuation of the absolute movement, which in the fourth section requires the lengthening of the lever by 1-16 in. (since 50,020 is a plus size) and shorten-

ing the lever of the third section by 17-64 in. (since 49,800 is a minus size).

"Condensing this method of correction, let

E equal the error, ...20 lb.
L equal length of lever, ...6.5 ft.
W equal weight of test car, ...50,000 lb.
m equal movement of the pivot.

"Then m equals, $\frac{\frac{L}{W}}{E}$

"Substituting values, 50,000 divided by 20 equals 2,500; 6.5 divided by 2,500 equals 0.0026 ft., or 1-32 in.

"Many useful deductions may be made from these tests and proofs. A load of 200,000 lb. uniformly distributed over this scale would reasonably weigh the aggregate of the four sections, but had a test been attempted with only 2,000 lb. the error in all four sections would have been as many times smaller as the test weight was smaller, in this case 1-25th. As the graduations on the beam advance from zero by 20 lb. steps no discrepancy in weight would have been noticed, and the scales would have been passed as correct. Thus from want of means to test it properly, the noted error of 200 lb. in the third section would have been but 8 lbs. if the scale were tested with 2,000 lbs., which amount probably would not have been detected.

"In testing track scales it will sometimes be noticed that sensitiveness has diminished to a serious extent, the divisions on the beam indicating that 20 lb. was the minimum amount to which any load could be determined, and now after two years' service it requires perhaps 60 lb. to hold the beam in a distinct position when no load is on the platform. A loaded freight car develops in many cases a still larger decrease of sensitiveness, requiring perhaps 100 lb. in either direction to settle the beam distinctly. The cause of this behaviour may have many origins; it is no doubt a sign of increased inertia and enlarged effect of friction, assuming that at one time the scale worked with the same sensitiveness both empty and loaded.

"The behaviour is the sum of all changed conditions. The elements of inertia are increased by the wear of the knife edges, which lowers the common center of gravity in all levers. The vertical connections have assumed an inclination angle, and the horizontal arrangement may be destroyed by yielding and settling of foundations, producing the vertical connection angle of effective influence. The elements of friction have increased by wear and corrosion, exposing greater surfaces to the minute oscillations during the process of weighing. It is the duty of the trial weight of sensitiveness to break the continued oscillations distinctly, and this cannot be done when the fracture takes place upon a plane, circular or flat, instead of an edge. The magnitude of the trial weight at once gives the observer an idea of the existing wear, and the test car put on the platform will assist in determining the future usefulness of the scale.

"As railroad track scales are usually installed in the freight yards without any roof to protect them against rain and weather, and often without proper drainage, it will be clear that destruction by rust is an active agent. The suggestion has often been advanced to apply oil to the wearing parts and vertical connections. When indiscriminately used more serious consequences are encountered than those ensuing from corrosion. Experiments made with lard oil and petroleum have not been entirely satisfactory. The oil spreading over the knife edges loosens their hold on the levers and sockets, and the loops and hooks slip freely into new positions, altering the vertical connections to such an extent that rebalancing is necessary, while the accumulation of dust upon a moist surface does not improve conditions or make them ideal. The proper lubricant should have great sluggishness of flow, be non-hardening in air or dampness, and free from acids. Its application should be only in places where its bad effects could not cause serious consequences.

"A comparison of eight main levers in one scale, four of which were lubricated, has shown that destruction by rust is greater than by wear and the result of lubricant has never caused any perceptible discrepancy. By the use of a proper lubricant, better service of such a scale can be obtained, without impairing its accuracy. It is not necessary thus to seek to prolong the life of a scale when it is in a dry pit. The increased inertia of old scales may be due to deflection in the levers when the scale is loaded. The transverse stress in long levers is very great, and by long service an alteration of form may have occurred, or at least there may be produced under load an amount of deflection within its elastic limit, which suffices to change the sensitiveness in a marked degree, say from 30 to 50 lb.

"To increase the sensitiveness of old scales, or the correction of defects from the causes stated is not always possible without great expense, involving in some instances rebuilding of scale and foundation. In other cases, the realigning of the levers, and often a complete resharpening of the knife edges and bearings, may be necessary.

"A slight improvement in the sensitiveness may be obtained by increasing the weight of the balance ball, which in all scales of this type may also be moved in a vertical direction upward for the same purpose. By raising the balance ball, the center of gravity is lifted to a higher plane, and this may give the required sensitiveness. Should these remedies not suffice, it is fair to assume that the friction is too great to be overcome by such measures, and the entire scale must be rebuilt or replaced.

"The increase in weight of rolling stock within the past few years renders many scales insufficient to sustain the weight of the new locomotives. Of course scales are not erected to weigh these engines daily, but they must provide for safe travel of the locomotives across them. A failure of the foundation, girder or scale can cause a serious wreck. Modern steel cars when loaded represent a weight of 160,000 lbs., or 80,000 lb. on each truck. During the travel over the scale it happens that in various moments the truck is completely balanced over one section and so imposes an immense stress successively to all of its parts. The calculations to resist these stresses must be based upon half its full amount per section and span; material proportioned according to these calculations would reach dimensions which are not often found in practice.

"When discrepancies in the weights returned by the scale are suspected or reported, the inspector should secure a loaded freight car, establish an equilibrium, and then add test weights of known value to the car in some manner. Assume that he adds a ton of these. If the scale shows this result on the beam, he has proved the scale will weigh both heavy and light weights. It must be understood that in this case the loaded freight car remains an unsettled quantity.

"It remains for the inspector to convince himself of the behavior of the scale under unequal loads, such as may arise from loaded cars with long and short wheel base. He aims to reproduce the exact conditions of service. Any loaded short-wheelbase freight car in conjunction with the test car, indicating about the full capacity of the scale, will develop deflection by measuring from the center of the span to a stationary point vertically below the bottom of the pit. This is often done by hanging plumb bobs from the timber before the cars are moved upon the platform and when under full pressure ascertained by the slack of the string. Both cars now weighed will indicate the prevailing sensitiveness and when the test car is removed, the remainder of the weight should be reduced by exactly 50,000 lb., because the section which supported the test car has been tested and corrected to that amount. It will be clear, that any possible plus or minus discrepancy is produced by deflection of the greater load somewhere. Switching the test car to the other end of the platform and the freight car to the position formerly occupied by the test car, a further comparison of effect is obtained."

To assist in understanding the points in Mr. Motchman's paper Fig. 75 is inserted. This is taken from the report of the sixth Annual Conference on Weights and Measures, in which it illustrated a paper by Mr. Epright (see

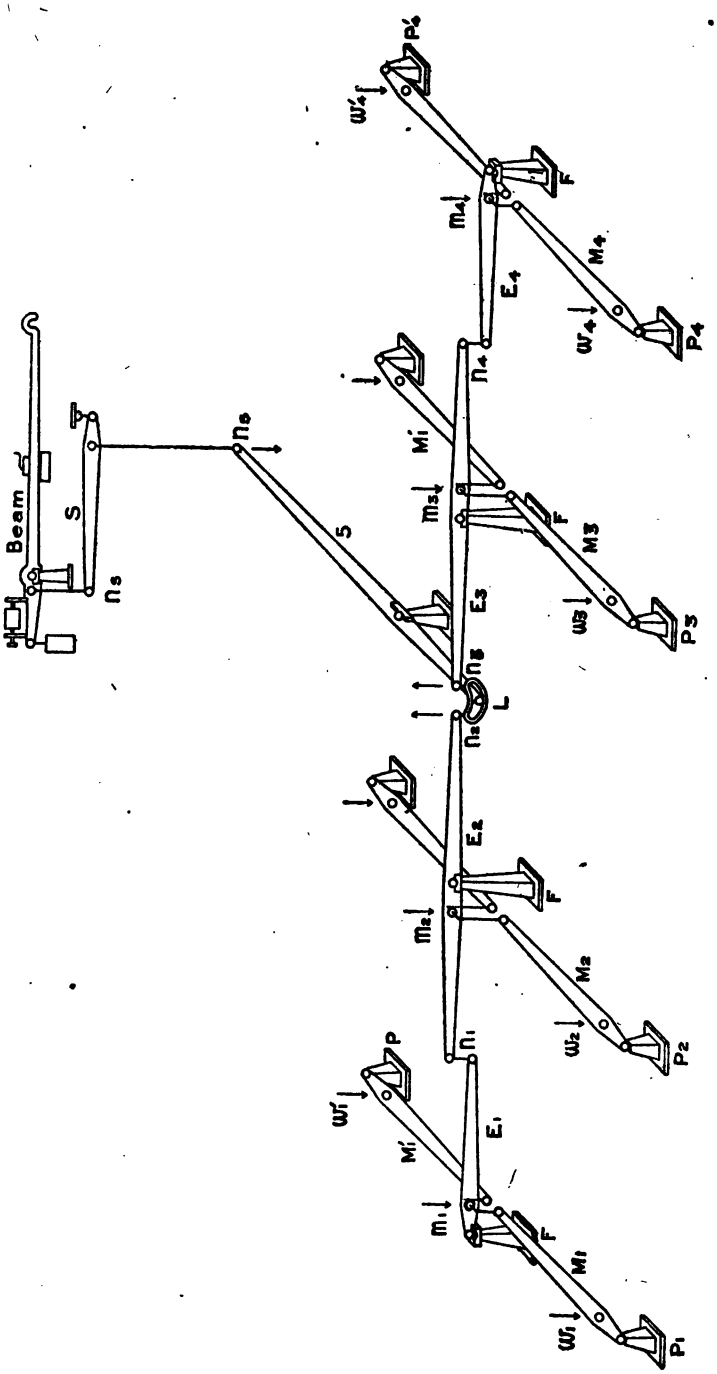


Fig. 75.—Scale Diagram.

Appendix B of this report). Describing the illustration, we quote from that paper:

"Referring to the diagram (Fig. 75): the weight of platform and load is carried on the main levers M, M_1, M_2, M_3, etc., at the points marked W. One end of each of the main levers is supported on a supporting post mounted on the foundation at the points marked P_1, P_2, etc., and the other end transmits the force of the load to the extension levers, E_1, E_2. E_3, E_4, at the points m_1, m_2, m_3, and m_4. The extension levers run parallel to the track and are supported on piers at the points marked F. The ends of these levers are connected by links, marked n_1, n_2, n_3, and n_4, by means of which the pressure of the load is transferred from the points m_1, m_2, etc., to the fifth lever "5" at L. The fifth lever conveys the combined force from all of the levers to the shelf lever S, from which it is conveyed to the beam. To assist in following the action the arrows are placed to indicate the direction of the force produced by the load."

Probably nothing more needs be said on this subject than to caution the reader upon the second last clause in Mr. Cruikshank's article. Before one begins to meddle with the nose irons he should make certain that it is not some other cause which produces the incorrect result.

THE SCALE DEPARTMENT.

While the organization of the scale department is wholly outside the province of the bridge and building men, it may be well to call attention to some of the features in different methods of organization. The most common method seems to be to entrust the care of the scales to the maintenance of way department, but there are excellent reasons for preferring the accounting department, as likely to secure better results. The engineering department should be utilized to the fullest extent in the planning of the installation and designing the weigh bridge, and the best results will probably be obtained where the supervisor of scales is a mechanical or bridge engineer. But in placing the control of the scale department it seems advisable that the purpose of the scales should be considered.

The purpose of installing the track scales is to obtain accurately the weight of freight in each shipment, in order that the proper charge may be made against it. The scale is in no way necessary for the movement of cars and freight. The roadway and bridges, and the engines and cars, are necessary for such movement. The former are under the care of the engineering department and the latter are under the care of the motive-power department. Both of these departments are on the debit side of the ledger and are subject to restrictions when economy is to be practised.

But the weigh bridge of the scale may be safe and the foundation strong beyond any danger to passing cars, and still it may be structurally weak to such an extent that it cannot be made to give continually accurate results; the engineer must balance the cost of this against bridge and culvert renewals. The superintendent of motive power must balance it against repairs to cars and engines.

The scale is properly an instrument for determining the charges for transportation of freight, and the collection of these charges is in the hands of the accounting department. It is therefore an adjunct of that department, and might well be under its control. The consideration in the mind of the maintenance men is whether the scale is "safe." The consideration in the mind of the accounting men is whether it is "accurate."

If the track scale is under the engineer of maintenance it is likely to be treated as a structure, and repaired or renewed as weakness or decay compare with other structures. It may be kept to a degree of accuracy only by constant attention. It may be losing the company money by slight but constant tendency to underweigh, and still may seem to be in fair repair, and be passed at the annual inspection, owing to the multitude of calls on this department for renewal of other structures.

If this track scale is under the department of accounts, the tendency of

the department will be to ask "Are we measuring our revenue correctly?" The accuracy of its work will be the standard by which the scale is measured, and it will be less likely to be slighted by this department, where its use is known and the need of accuracy is recognized.

One serious danger seems to threaten this plan. If the control of the track scales was assigned to some minor accounting official, it might be that this official would attempt to assume charge of the work and possibly overrule the scale supervisor. But with a Supervisor of Scales equal in ability to the Bridge Engineer, and given equal pay, reporting to the general auditor or controller, and given certain authority over the weighmasters (at least to the extent that his approval be necessary before their appointment and that his request should ensure their dismissal), the chances for good work from the department would be greatly improved.

THE SCALE SHOP.

Where a road has twelve or more track scales, it would seem that a scale shop were desirable. It seems impossible to fix any rule as to what the shop equipment should be, and in fact this will depend largely on the efficiency of the men employed. On smaller roads it may be possible to combine the scale shop with the pump shop. The scale shop may be equipped with its special facilities, and depend on the general machine shop and blacksmith shop for work in their line. The absolute necessities appear to be the apparatus for adjusting and sealing, and the beam for testing the test weights. Benches, vises, hand tools and a power emery grinder also appear essential. Beyond this each case must be a separate problem.

For detailed information reference is made to Appendix A. The replies there given have been in some instances followed up, and the following are given as the opinions of those with experience:

A road with 12 to 30 track scales and the complement of other scales should have a shop 20x24 ft., with a concrete sealing platform 4x6 ft. The floor is preferably of concrete, all except the sealing platform to be covered with flooring. The building is preferably of brick or concrete. It should have a forge and anvil, lathe, drill press, power-driven emery grinder, bench and bench tools, set of weights and a complete apparatus for sealing scale levers.

A road having from 30 to 50 track scales should have a building about 30x50 ft., equipped with a lathe, planer, reamer, two drill presses, emery wheels, bench and bench tools, forge and anvil and tools, an elevated track for one man to handle any of the levers, slotting machine, straight edges and gages, a master even balance beam for testing test weights, set of standard weights, a master scale for testing test cars and minor tools.

For a similar road which would also build its own scales, is recommended a building about 40x80 ft., of brick or concrete, with floor of wood except a concrete floor for sealing purposes. It should have a lathe, planer, shaper, two drill presses, two emery wheels, and complete sealing device for sealing all levers, also a complete set of weights for sealing purposes, from 1-64 oz. up to 5 lb., and one each 6 lb., 10 lb., and 50 lb. sealed weight. There should be a forge 3 or 4 ft. diameter, sufficient reamers for reaming out all kinds of loops, a buffer for polishing beams and sufficient bench and bench tools. There should be also a master scale and equipment. This last is in view of the purchase of all castings (as the roads so largely buy other castings) and the purchase of the beams.

As to the force needed:—Up to 12 scales, the first shop could be handled by the scale inspector while not on the road. With more scales, a scale man should be employed to put in all his time at the shop, and the inspector should also work there when not on the road. The second shop would probably require one or two regular men, and possibly a helper, in addition to the time which the inspectors could give. The third shop should have the attention of the chief inspector, and should have a blacksmith and helper and a machinist and helper, also all the spare time of the road men.

These three systems are being used and are giving excellent results in different parts of the country. For a more complete scale department the reader is referred to the report of the Scale and Weighing Committee of the American Railway Association.

SCALE REPAIR CARS.

Several roads report having repair cars fitted up with everything necessary to build or repair a scale. The use of such cars is in conflict with the recommendation of the American Railway Association. We quote the following from Mr. Romig:

"Repairing scales in the field should be attempted only by the replacing of duplicate parts by new or repaired ones. It means that the repairs must be done in shops where machinery is not adapted to this class of work, consequently pivots and bearings may not be hardened properly. Bearing surfaces which should be from 4 to 6 in. long are reduced. True emery stones or grindstones are not to be found in 99 per cent of machine repair shops, making it almost impossible to grind the parts true. Straight edges and gages for doing scale work can not be carried with the test car, as there are a number of them. They, also, must be kept true and straight. It will be no more practical to carry equipment to make scale repairs than it is to carry the necessary equipment to make engine repairs."

However, there is quite a range of work which may be done in an outfit car in the opinion of the Atlantic Coast Line, Kansas City Southern and Southern Pacific roads. The car used by the latter road is described as being an old coach fitted up for the purpose, being divided into three parts, each 15 ft. long. In one end is a kitchen (also used for dining room). In the center is a sleeping and lounging room; in the other end is the scale shop, fitted out with tools sufficient to rebuild any scale on the road. The car is an old passenger coach and is equipped for being handled in passenger trains. In this car are carried 200 weights of 50 lb. each, for testing wagon and other scales along the route.

As some of the equipment mentioned in the preceding clause about shops may be unfamiliar to some of our members a few illustrations showing

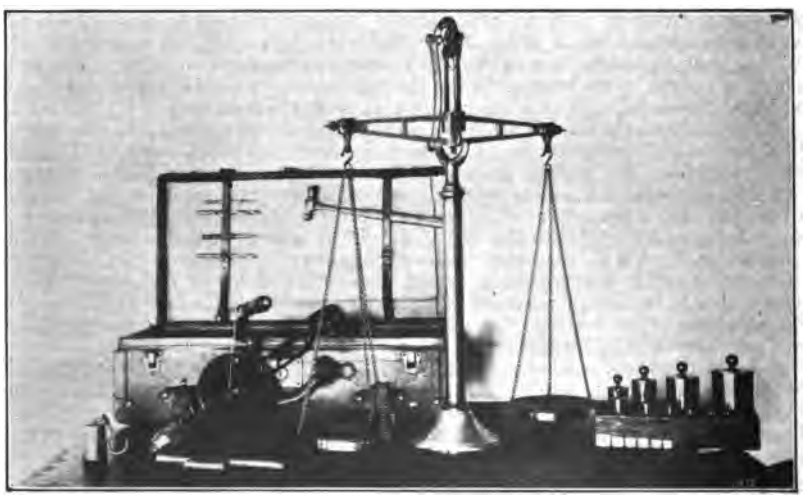


Fig. 76.—Portable Sealer's Balance and Outfit.

sealers' scales and outfits are shown in Figs. 77 to 83. For the photos from which these were made we are indebted to Mr. A. W. Epright, scale inspector, Pennsylvania railroad.

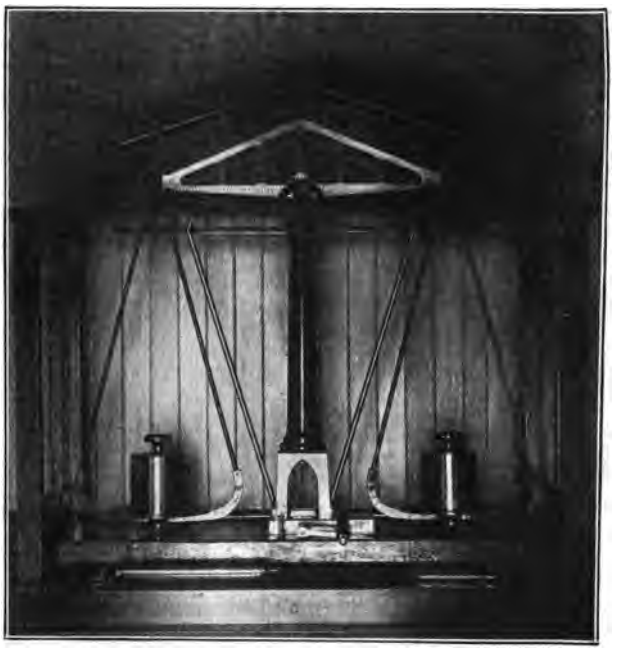


Fig. 77.—Office Balance for Sealing Large Weights.

SHOULD RAILWAYS BUILD OR BUY THEIR TRACK SCALES?

The list of questions sent out included the following: "Have you considered building your own scales?" To this 18 roads replied in the affirmative. Eight of these do and ten do not build their scales. Of the ten, one gives no reason for or against; four are opposed to building, and five are in favor of building. The first of the four stated the following reason for its unfavorable opinion: "It is not thought to be economical, and many good features of scales are patented."

In reply to a personal letter this correspondent replied: "Referring to patented features, it is generally recognized that the suspension platform scale is the most desirable type of construction. Mr. Epright has one design which has been patented. The Fairbanks Co., the Buffalo Scale Co., and the Strait Scale Co., and perhaps others, have designs which have been patented."

The question of patents on the suspension device seems likely to be threshed out soon in the courts. Two cases of infringement are reported at the present time.

The other objections are as follows: (2) "The saving, if any, does not seem to justify it. (3) We decided not to build scales as there is a factory located on our line." (4) "It requires considerable help to handle a shop for building scales, also competent men. We do not consider we would save any money."

Those roads favoring building their own scales, give the following reasons. (1) "More ready supply of repairs." (2) "Think we could make them

better and cheaper. Beams would have to be bought." (3) "Can build cheaper than we can buy them." (4) "Uniformity, cheaper and less delay." (5) "Cheaper and better." It will be noticed that these, like the foregoing, give their opinions from investigation, and not from such practical experience as comes from having this work in hand for a period of years.

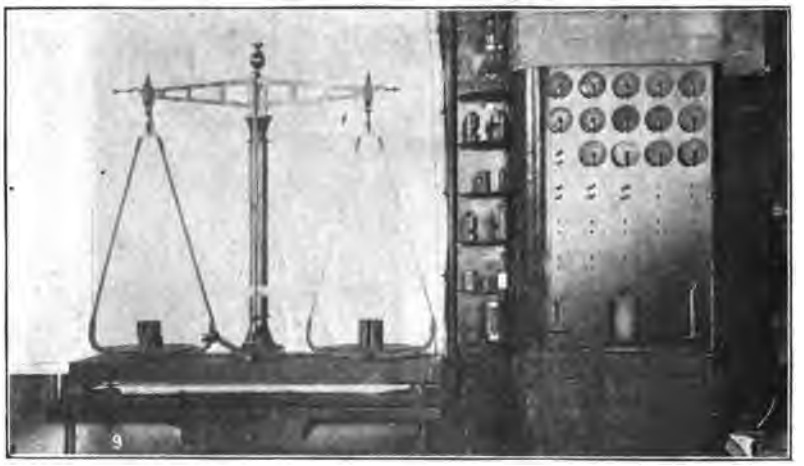


Fig. 78.—Office Balance for Sealing Small Weights.

Fig. 79.—Beam of the Master Scale, Cupboard and 12 Test Weights.

Of the eight roads who build their own scales, every one is in favor of so doing. This seems a vital point. Of those who investigate only, four are opposed to building and five favor building. Of the eight having practical experience, all favor building the scales. The reasons given are as follows: (1) "We do it cheaper and get a better scale." (2) "We are building

our own scales, and have done so since 1888. Have found it economical to do so." (3) "We can build scales cheaper than we can purchase them. Also have a uniformity of scales and have parts to make repairs in case of breakdown without calling on the scale manufacturers." (4) "They can be built cheaper at our own shops and all repairs are cheaper, and we are not at the mercy of a scale company." (5) "It is more convenient and cheaper." (6) "The cost is less and the work better." (7) "By building our own scales we can have a uniform and interchangeable scale. We are not afraid to use metal as our aim is to get beyond deflection. If we do this, and our levers, etc., are built on proper lines, good results are sure to follow; and in case of breakdown, the scale is soon in service again by the use of a duplicate part." (8) "We can make them about 50 per cent cheapeer than we can buy them."

Turning back to the unfavorable replies, the objections made by these four correspondents are: "Not economical"; "Saving does not justify"; "Much competent help needed and no saving." As these may be typical of the objections urged elsewhere, it may be well to consider them. The question of economy of building as against buying must be settled for each road for itself. If a road already has its own repair shops, and one at least well fitted, it is but a step to build its own scales. Roads buy most of their castings now. It will violate no tradition to buy the scale castings, and some doubt the advisability of making their own scale beams.

It is noted that all who do build their own scales believe they get a better scale and get it at less cost. In this relation the committee has encountered one significant item. No less than eight representatives of one of the older scale companies have told the chairman that some railroad was now buving scales when it had formerly built them, and in but one of these cases was there any truth in the report. In that one case it was found upon investigation that a road which for many years has been building its own scales with platforms 40 ft. long had bought from the scale company one scale having a 52-ft. platform.

Answering the objection that a large force of skilled men would be required for building the scales, it may be said that one road of 4,800 miles, with 65,000 freight cars and 116 track scales, has built its own scales for many years and is able to take care of repairs and renewals with a shop force of four men (a machinist, blacksmith, and two helpers). Four outside men also work in the shop a part of the time.

In 1909 the chairman of this committee was in charge of maintenance of a small road and needed two new track scales. The scale company asked $750 each. A connecting road which had a contract with the scale company was buying the same scale for $400, and was receiving a rebate of $75 each for the old scales replaced. The scale company made this contract to keep the railroad from building its own scales.

The principal advantage to a railroad from building its own scales comes in the matter of repairs and renewals and the minor changes. A track scale may be giving good service in everything except pivots or knife edges. A new set of pivots, bearings and bearing blocks might make the scale equal to the service requirements. If the road is building its own scales these parts can be strengthened at nominal cost, by a change of the pattern, and giving a little more metal. Scale companies are no exception from others who make high charges for special work. It is difficult to get a scale company to make such special parts, and if it does the overhead charge will be perhaps 400 per cent.

In investigating this phase of the subject, your chairman took one of the standard makes of scales, and planned some changes, such as increasing the knife edge in the primary pivot from 6 in. to 9½ in., and others proportionately, with bearings and supports to correspond, and some other minor changes. A careful estimate was made of the cost of new patterns for such castings as would have to be changed, and the extra amount of material used

was estimated at a fair price. It showed this would increase the cost of each scale (dividing the cost of pattern between four scales) by a little less than $200.

The purchasing agent of a railway system asked the makers for a proposition on four scales of the standard pattern and four with the desired changes. The first were priced at $625 each and the latter at $1,540 each. A company building for itself was then given the same changes as between the scale they were building and a new one, and asked to state the difference in cost. It placed the cost by its standard at $447.50 each, and four with the changes at $733.65 additional, making the latter cost $630.91 each.

It is recognized that a large proportion of the scales now in service will have to be abandoned and different types substituted, owing to increased loads and the demand for higher average accuracy. Assuming a road having 2,500 miles of track and 31 track scales, it would average the renewal of about four scales per year. Assuming that it makes the changes as above outlined, the cost to the road will be $6,160 per year if it buys the scales from the maker, and $2,523.84 if it builds them in its own shops. The committee is not at liberty to publish the names and descriptions of these scales, but the figures can be verified by enquiry of any road which builds its own scales and making enquiry also of the manufacturers.

SHOULD RAILWAYS PURCHASING SCALES USE THEIR OWN SPECIFICATIONS?

In the answers to our questions, as shown in Appendix A, it will be seen that 8 railroads (having 451,000 freight cars) build their own scales and 6 railroads (having 285,000 freight cars) have scales built to their own plans or specifications or both, while 75 railroads (having 1,375,000 freight cars) buy what the scale manufacturers offer.

The American Railway Association adopted in May, 1913, a report on track scales which fixes many points in scale practice. This will greatly simplify scale matters. (This report is hereto attached as Appendix F.)

In Appendix C is a valuable paper by Dr. Reichmann, and attention is called especially to his remarks regarding what should be embodied in a specification. Note also that he says: "No scale should be accepted until it has been tested to its full capacity." In a letter to the chairman in March, Dr. Reichmann wrote as follows: "In a scale of 150 tons capacity, the main levers should be of steel; other levers may be of cast iron. For 100 tons capacity they all may be of cast iron. Standards supporting levers should be of cast iron. Define scale irons of certain length. Define effective platform the length determined by overhang desired. Test the scale to half its capacity on each section to show the sensitiveness (when new) of half the smallest division. If the scale is graduated to 50 lb. on the beam, the sensitiveness should be 25 lb. Of course, after the scale has been in use, if it is sensitive to 1 lb. to the ton it will be in very good condition."

Three specifications for track scales have been submitted to your committee: (1) the "model specification" of the Standard Scale Co.; (2) the specification of the Bessemer & Lake Erie Railroad, published in Bulletin 148 of the American Railway Engineering Association (and republished in the Railway Review for August 22, 1912); (3) a specification proposed by Mr. O. E. Selby.

The committee submits below a suggestion for a scale specification, and in its preparation the three specifications noted above have been consulted, as have been also the paper by Dr. Reichmann and the report of the American Railway Association. It is hoped that this will assist in bringing our track scales up to the standard required by the last named report, and that it may be a help towards perfecting specifications for scales, but it is not offered as a complete work to be adopted or followed blindly.

SPECIFICATIONS FOR TRACK SCALES.

Description.

Weigh rails shall be .....ft. long.
Scale shall be .....ft. long between pivots of the two end sections.
Scale shall have a rated capacity of ..... tons.
The rated capacity shall be twice the maximum live load imposed upon any one section.

Type.

Scales shall be of the ..... type of scale, and shall comprise a complete weighing machine ready to be set on the masonry and to receive the weigh bridge.

Plans.

Bidders shall submit stress sheets, general plans and descriptions showing arrangement, dimensions and sections sufficient for verifying the unit stresses and features of design, and the estimated shipping weight of the scale shall be given in the bid. After acceptance of the bid, the contractor shall furnish detail plans of all parts, which shall be subject to the approval of the designated representative of the railroad company.

Patents.

If any patented devices, parts or combinations are used, the contractor shall protect the railroad company against all claims on account of such patent.

Sections.

Each point where both girders of the weigh bridge make connection with, and transfer the load to, the weighing machine shall constitute a section.

Dead Load.

The dead load shall consist of the load permanently supported on the scale above the bearing feet, and unless otherwise specified shall be taken as ..... lbs. per ft. of weigh bridge. The weight of levers may be neglected.

Live Load.

The live load shall consist of a train of typical car loads with axles spaced as shown by the diagram below, and with axle loads of ..... lbs.

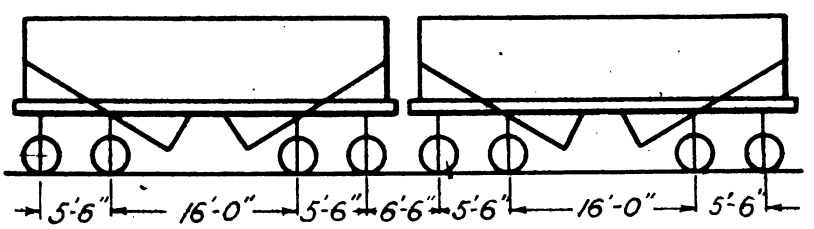


Fig. 39.

The maximum reactions on the sections shall be computed for any position of the specified live load on the assumption that the weigh bridge consists of simple non-continuous spans, and the greatest reaction on any section shall be used for designing all levers and supports.

Longitudinal Force.

The longitudinal force shall be one fifth the maximum live load on the platform.

Impact.

In computing the live load section reactions, the axle load in position at the end of the platform (that is, just entering or leaving the scale) shall have 100 per cent added for impact; otherwise the live load shall be used without impact.

Multiples.

The multiple of the beam pull shall not exceed 800. Where a Streeter-Amet recording machine is to be used, it must not exceed 400. Bidders will show all the multiples to the beam.

Bearings.

The load from the weigh bridge shall be transmitted to the main levers by central bearings designed so that the distribution of the load over the length of the pivot will be uniform and not affected by deflection of the weigh bridge, and so as to permit of free longitudinal and lateral movement of the platform.

Limiting Movement.

The lateral and longitudinal motion of the weigh bridge shall be restricted within safe limits either through the design of the scale or by means of appliances, but the accuracy of the weighing machine must not be affected in any degree by the action of such appliances.

Unit Stresses.

The unit stresses due to a combination of all loads specified shall not be greater than the following:

	Pounds per Square Inch		
	Cast Iron	Cast Steel	Wrought Iron
Tension or extreme fiber stress on tension side in bending,	2,000	5,000	8,000
Compression,	10,000	12,000	
Bearing,	10,000	12,000	
Torsion,	400	1,000	

Masonry,—Bearing (lb. per sq. in.) 300.

Steel Pivots,—Extreme fiber stress in bending (lb. per sq. in.) 16,000.

Bearing on Knife Edges, (lb. per lin. in.) 5,000.

Cylindrical Surfaces,—Line bearing on cylindrical surfaces. (d = diam. cyl. in.)

Cast iron, 400 d.

Cast steel, 600 d.

Maximum Deflection in Levers,—

Cast iron, .04 in.

Cast steel, .08 in.

In determining the bending moment, the lever arm should be defined as half the length of the bearing surface in the loop or connection, plus ¼ in., plus the difference between the dimensions of the friction faces in the loop and friction faces in the lever, as expressed in the following formulas:

Let L equal lever arm required,

l equal bearing surface in loop,

T equal distance between friction faces of loop,

W equal width of boss or sustaining member enveloping pivot,

Then, $L = \frac{1}{2}\, l + (T-W) + \frac{1}{4}$ in.

Beam.

The beam shall be of cast steel with numbers on brass, but a beam of equal rigidity of other material may be substituted by agreement.

The beam shall be graduated in 1,000-lb. intervals, not closer than five notches to the inch, up to 200,000 lb., and shall have a roller poise carrying an auxiliary sliding poise of brass, sliding on a brass beam, graduated in 50 lb. intervals up to 1,000 lb.

The beam shall be so stiff that under the working load applied in a testing machine the deflection of the tip from the line of the pivots will not exceed 0.01 in.

There shall be no loose weights.

A type recording beam shall be substituted if desired.

Sensitiveness.

The scale shall have sensitiveness to a platform weight of 25 lb.

Adjustable Poise.

An adjustable poise for bringing the scale into perfect balance shall be provided. It shall be provided with a set screw or other appliances so that it cannot be moved without use of screwdriver, wrench or other tool.

Materials.

Main levers shall be of steel castings. Other levers shall be of cast iron.

Loops, links, rods, etc., shall be of wrought iron, but cast steel may be substituted by agreement.

Stands, yokes, arches, bearing feet, etc., shall be of cast iron.

Where the design shall call for members tying stands or other parts together, such members shall be of cast iron, wrought iron, or cast steel; no rolled structural steel shall be used.

Materials shall conform to the specification for material and workmanship for steel structures, of the American Railway Engineering Association, and said specification shall also govern as to inspection and painting.

Details of Design.

Parts shall be designed with ample room for inspection and adjustment and so that members may be removed and replaced easily.

Parts occupying similar positions in the scale shall be made alike and interchangeable.

Knife edges of pivots shall be accessible for inspection without the removal of any part.

Pivots and pivot bearings shall not be cast in levers or bearing blocks, but shall consist of separate units. Levers and bearing blocks shall be accurately machined to hold these pivots and pivot bearings, which latter shall be made to a standard size, and interchangeable as to the different levers.

The range of pivots to facilitate easy working of the scale shall not exceed ⅛ in. per foot in length.

Main lever stands shall be connected transversely by non-adjustable members which will fix their relative positions independent of measurements on the masonry.

Bearing feet shall be braced together in pairs transversely where construction will permit.

Bearings of clevises, loops, yokes, etc., shall be line or surface bearings; point bearings shall not be used. All line or surface bearings shall have bearing their entire length.

Bolts, rods, screws, etc., shall not be less than ¾ in. diameter.

Threads shall be U. S. standard.

Lock nuts shall be provided on adjustable parts.

Workmanship.

Castings shall be faced where they bear on masonry, on steel members, or on each other, and shall be finished to a template and made interchangeable.

Bolt holes shall be reamed or drilled to a diameter 1-32 in. larger than that of the bolt, except that oval holes and holes for masonry bolts may be clean cored holes.

Each lever shall have two leveling tabs, cast about 2 ft. apart, and accurately finished parallel with the pivot line.

Pivots shall be of special alloy scale-pivot steel, accurately ground and hardened by a method approved by the buyer. They shall be accurately lined with their knife edges in a true plane, except for range variation.

Pivot bearings shall be of hardened bearing steels with faces cylindrical in form.

The bidder will be permitted to substitute for the steels approved by the purchaser for the pivots and pivot bearings, any steel of his own selection provided he will guarantee that such steel in pivots and pivot bearings will give a service of one million cars in gravity weighing, or 167,000 cars in spot weighing, without showing wear to the extent of 1-64 in., or becoming sluggish to the point of requiring over 100 lb. on the platform to change the position of the beam.

Foundation Plan.

The foundation plan shall be approved by both the railroad company and the bidder. Duplicate plans shall be on file with each. The foundation will be installed complete by the railroad company, which will notify the scale company when this is ready for the installation of the scale.

Weigh Bridge.

The plan for weigh bridge shall be approved by both the railroad company and the scale company. Each shall have one or more copies of the plans, which shall be exact duplicates. The weigh bridge will be furnished by the railroad company, which will also furnish 100 lb. T-rails for scale rail and dead rail, all material for installing scale (except weighing machine), and build scale house and all appurtenances.

Superintendence.

The bidder will be notified when the foundation is complete and weigh bridge ready for installing, and he shall furnish a competent erecting foreman to superintend the installation of the scales. He shall have charge of installing the scale and placing the weigh bridge and the scale rails, both on the scale and the approaches.

Any and all assistance and tools needed will be furnished by the railroad company.

Acceptance.

When the scale shall have been installed and pronounced ready for service by the erecting foreman, as the representative of the scale company, the scale shall be subjected to an acceptance test as follows:

First, a test car with a short wheelbase, not over 7 ft. 6 in., and weighing 50,000 lb. (as near as may be), shall be rolled onto the initial end of the scale and the scale tested on each section with the car. The car shall then be rolled off, and then rolled back from the farther end, and each section again tested. The car shall then be placed on some part of the scale, and 1,000 lb. of test weights added to the car and the beam tested. Then 100 lb. of these weights shall be removed and the beam again tested.

Then the car shall be removed, and a heavily loaded car set on the scales, so placed as to leave room at one end for the test car, and the weight obtained. The test car shall then be placed on the scale and the

weight obtained. Then shall be added to the test car 3,000 lb. of test weights, testing the beam as each 1,000 lb. is applied. Then remove 100 lb., 200 lb., 200 lb. and 500 lb., testing the beam at each removal.

Then remove the test weights, shift the freight car and test car so that each occupies the end of the scale previously occupied by the other, and repeat the test. At each test balance the beam twice, once by bringing the poise from a lower weight up to a balance and once by bringing poise from a higher weight down to a balance. At each of the above tests the scale shall correctly weigh test car and test weights.

Before deciding on suggesting the above acceptance test a much more exacting test was proposed. Copies of this were sent to all of the scale companies, to members of the committee and to a dozen others. It was possibly too severe a test, and after considerable consideration it has seemed best to modify it as above. The specification as sent out originally was as follows:

"After this scale shall have been fully installed, adjusted and tested by the maker's representative, it shall be tested on behalf of the purchaser in the following manner:

First, a test car with a wheelbase not over 8 ft. and weighing (as near as may be) 50,000 lb. shall be brought on to the scale from the initial end and the scale tested with this car on each section. The car shall then be rolled off the scale and rolled back on from the farther end and the tests repeated over each section and the car rolled off. There shall then be placed upon the scale test weights to the amount of 50,000 lb. and the scale tested at the first 10,000 lb., at each 5,000 lb. thereafter until 30,000 lb. are on the scale, at each 2,000 lb. until 40,000 lb. are on the scale and at each 1,000 lb. until the entire 50,000 lb. are on the scale.

Then the test weights shall be removed and a fully loaded freight car shall be pushed upon the scale. This car should weigh as near as may be (with its load) 150,000 lb. There shall then be added to this load the test weights before mentioned. The scale shall be tested at each 1,000 lb. until 30,000 lb. of test weights have been added. It shall be tested at each 500 lb. thereafter until the car, with the test weights, shall aggregate the 200,000 lb., the capacity of the scale.

Test weights shall then be removed at the rate of 100 lb. at a time and the scale tested each time until 1,000 lb. have been removed. At each of these tests the beams shall be brought to a balance twice; once by pushing the poise from the lower to higher weight and once by bringing it from a higher to lower weight and the scale shall show accurate results at each test."

A very large percentage replied and the replies showed it to be a live subject. The Buffalo Scale Co., by T. L. Richmond, president, writes:

"In regard to testing, we are inclined to think you would find it difficult to transport 50,000 lb. of hand weights in addition to the test car, and that you would gain but little over and above the test you would make with a thoroughly reliable car that weighed 50,000 lb. When one considers that weather conditions may easily affect a scale 25 to 50 lb., we would think it wiser and more practical to test out the beam notches in some other way than that proposed, and that is really all you gain by the latter part of your test. The test car will determine the accuracy of the scale on the various sections."

The Howe Scale Co., of Illinois, by C. B. Smith, secretary, writes suggesting the substitution of the following:

"A test car with a wheelbase not over 8 ft. and weighing as near as may be 50,000 lb. shall be brought on to the scale from the initial end and the scale tested with this car on each section. The car shall then be rolled off the scale and rolled back from the farther end and the tests repeated over each section, and the car rolled off. There shall then be placed upon the scale test weights to the amount of 50,000 lb. and the scale tested at the first 10,000 lb., at each 5,000 lb. thereafter until 30,000 lb. are on the scale; at each 2,000 lb. until 40,000 lb. are on the scale and at each 1,000 lb. until the

entire 50,000 lb. are on the scale; then replace the test car on the scale and add the test weights in 5,000-lb. or 10,000-lb. lots until the entire 50,000 lb. of test weights are on the scale, thus securing the combined car and weight test of 100,000 lb.

Then the test car and test weights shall be removed and a fully loaded freight car shall be pushed upon the scale. This car should weigh, with its load, as near 150,000 lb. as possible. There shall then be added the test weights in lots of 10,000 lb. until 30,000 lb. of test weights have been added; then in lots of 5,000 lb. until the entire 50,000 lb. of test weights shall be upon the platform. In all tests using the test weights the weights shall be approximately of uniform distribution over the entire length of the platform. The test may be reversed if so desired. At each of these tests the beam shall be brought to a balance twice; once by pushing the poise from the lower to the higher weight and once by bringing it from a higher to a lower weight, and the scale shall show accurate results at each test."

Eugene Motchman, of the Standard Scale Co., contributes the following:

"If the committee establishes the maximum operative capacity at 100 tons, the scale may be designed for 150 or 200 tons to meet long service and safety, yet the test of accuracy need not exceed the amount railroad companies handle, and upon this consideration a 50,000-lb. test car meets the present requirements fully. To test a traffic scale upon its nominal capacity of 150 or 200 tons can better be done by the engineer who is familiar with calculations on fibre stresses than by the inspector who travels with the test car, unless he is provided with a schedule giving the dimensions of the girders and levers for the corresponding spans and weights acting at certain points to check them up.

"It is true that all adjustments made under a greater pressure proportionately reduce minor deficiencies of the always present deflection, and thereby include as corrected all intermediate weights from zero to the amount of the test car per section, and if the limit of freight cars does not exceed 200,000 lb. no section will be taxed harder than by the test car. To test the scale by separate test weights of 50 or 100 lb. each, to any intermediate amount from zero to 50,000 lbs., would be a waste of time. It would only establish the spacing of the notches upon the weigh beam and this can better be done with a pair of dividers or inspection of scales during erection, to which any purchaser is invited."

The committee may safely recommend a test with two 50,000-lb. cars upon 8 ft. wheelbase in cases where extreme accuracy is required, approaching thereby the conditions existing in actual service and removing in this manner all skeptical doubts. Experience has shown that a test car in total can be kept a standard weight upon a master scale without great expense; a collection of 1,000 pieces of test weights become in a short time a doubtful mass when lugged from one end of the line to the other. Some test weights should be carried upon a test car to cover the indication of the front beam, which is 1,000 or 2,000 lb.; also one 10-lb and two 20-lb. weights, to determine the sensitiveness of the platform."

Mr. O. E. Selby, of the C., C. C. & St. L., writes as follows in regard to this point:

"Referring to your proposed clause covering the test of the scale, it occurs to me that the use of 50,000 lb. of test weights outside of the test car will call for more weights than ordinarily are available. You say, 'The scale shall show accurate results at each test,' but no limit of tolerance is given. For a new scale, the weight should be correctly shown within 20 lb., but for old scales possibly 50 lb. or more should be allowed."

Mr. E. D. Levy, St. L. & S. F., writes as follows:

"In regard to the clause covering the acceptance of a scale from the manufacturers, the specifications are good, but a small line would find it

very hard to make as severe a test as this clause covers. I doubt the ability of this road to make such a test without first investing in a large amount of sealed test weights. These weights, of course, necessarily must be resealed frequently in order to keep them in perfect seal. This process is expensive. If a number of scales were being purchased at the same time, it would perhaps be more economical to make the test at the factory. The scale could be set up with framework substituted for a platform, and the scale tested with sealed weights or any other objects of known value.

"We have found that if a scale will weigh correctly at one weight it will weigh correctly at another, providing, of course, that the test is sufficiently severe and further providing that the beam is accurately graduated. I notice in the specifications an absence of allowance for variation. We have built many scales and I have yet to recall a scale that tested absolutely perfect, even on a load not to exceed one-quarter of its total capacity. In reality, of course, the scale should be tested in all different positions and at the various denominations on the beam, to see that no fault exists. This is really the right way."

Mr. H. T. Porter, of the B. & L. E., writes:

"The test you suggest is probably all right for testing newly installed scales, before they are accepted, but is too elaborate for the test you make from time to time to determine whether they are in adjustment and are working accurately."

Mr. L. D. Davis, of the B. & O., writes:

"It is thought the test as recommended is too elaborate for regular practice and it could not be performed on a number of scales on our line. You can appreciate the length of time it would take to make the test."

It will be noted that all the railroad men quoted recognize the desirability of such a test and object only on the ground of lack of test weights and time required. The former objection can be overcome by using, say, 30,000 lb. of previously tested scrap iron. Our proposal was merely a suggestion and it is hoped that it may be criticised and a better method developed.

ACKNOWLEDGMENTS.

The committee wishes to return its thanks to the 138 members of the Association who have rendered assistance in securing data for this work, and to 162 officials of various railways for similar assistance. These are too numerous to name, but although unnamed, their help has been appreciated. To Mr. W. M. Camp, Mr. E. T. Howson, Mr. F. W. Lane, Mr. E. E. R. Tratman and Mr. K. L. Van Auken of the technical press we are under many obligations for information and for back numbers from their files. Mr. A. W. Epright, Mr. L. D. Davis, Mr. F. C. Maegley, Mr. G. D. Merrick, Mr. F. H. Schlinkert, Mr. O. Maxey and Mr. W. E. Wells are among the scale department men who have helped when help counted. Mr. A. S. Dodge, of the Western Weighing Association, helped us materially. Mr. A. Bousfield, Mr. H. O. Hem, Mr. E. Motchman, Mr. Fred Cruikshank and Mr. R. W. Romig are among the scale men who assisted us. Mr. A. R. Raymer, Mr. H. T. Porter, Mr. L. L. Sparrow, Mr. H. L. Dresser and Mr. W. A. Clark are among the engineers who took time and pains to furnish assistance and to put us in possession of desired information.

CONCLUSION.

In conclusion, your committee has tried to make this report one which will be a help to a bridge foreman or a young engineer, and perhaps a help also to those who are trying to improve track scales and their work of weighing cars. It is not expected that it will contain much that is new to the scale men. It was written for the inexperienced man rather than the expert, but it contains the views of several experts. The most important matter is

in the parts on installation, maintenance, inspection, testing and adjusting. It was thought that the matter preceding installation would help to the understanding of these problems, and it did not seem advisable to conclude without an attempt to do something towards meeting the problems of repair-shop work, specifications and the question of whether railways should build or buy their track scales. The matter of organization and control of the scale department has been touched upon, and this is worthy of the attention of managers, in the interests of the railways and their revenue.

COMMITTEE.

The report on Track Scales was compiled by a standing committee consisting of A. M. Van Auken (Chairman), C. E. Smith, R. C. Sattley, H. M. Jack and G. H. Soles. The report was revised slightly to appear in its present form but represents the work of the committee in all important particulars. The chairman was responsible for the bulk of the work in the preparation of the report. (Committee on Publications.)

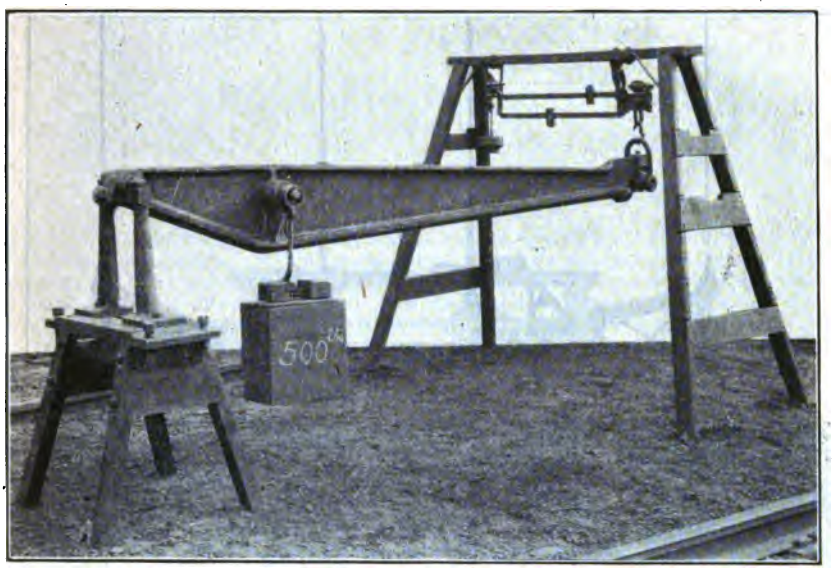


Fig. 80.—Suspending an Extension Lever of a Track Scale for Sealing.

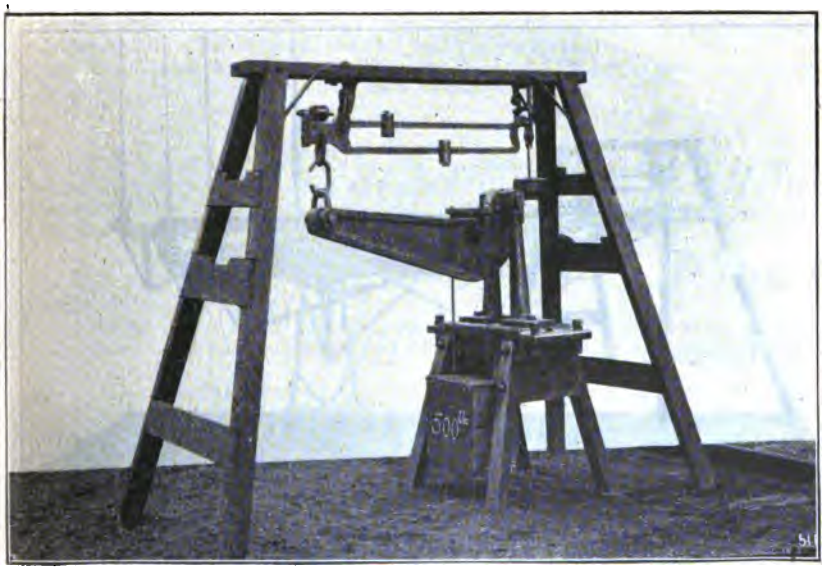


Fig. 81.—Suspending a Cross or Main Lever of a Track Scale for Sealing.

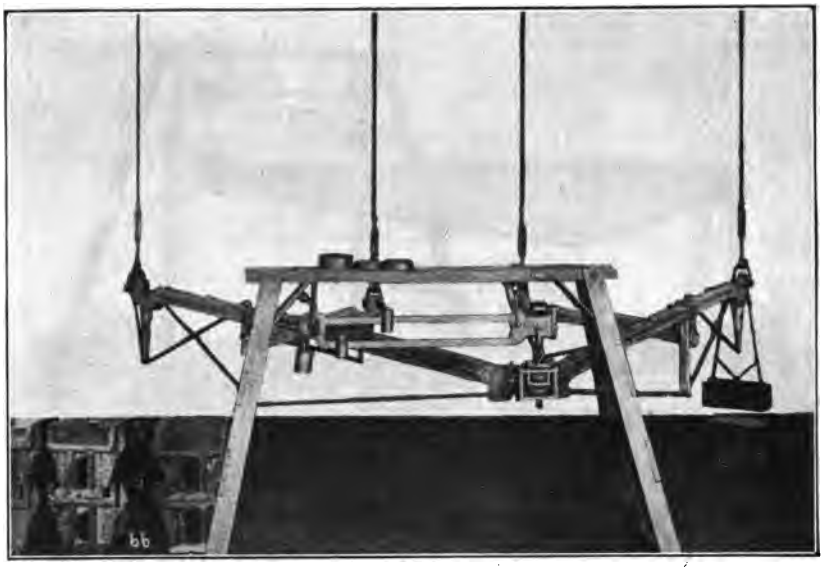


Fig. 82.—Suspending the Levers of a Wagon Scale for Sealing.

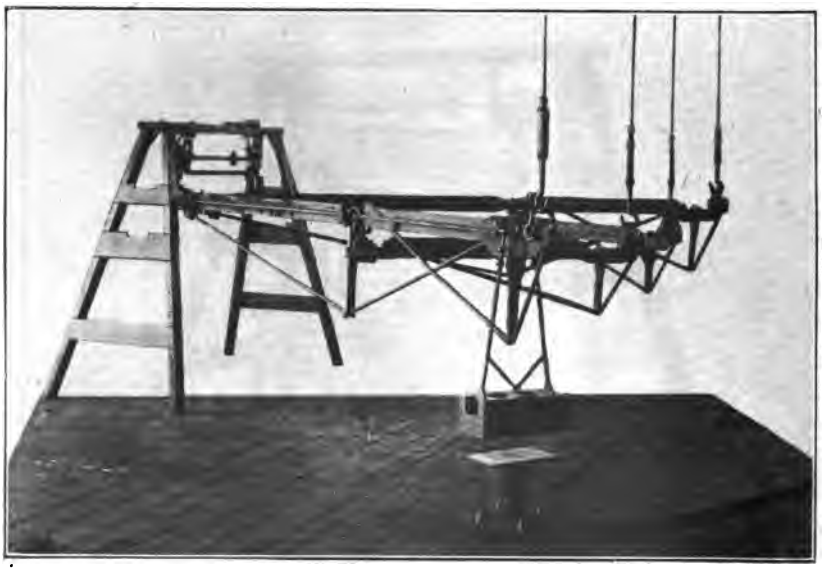


Fig. 83.—Sealing the Levers of a Wagon Scale.

APPENDIX A.

The Committee on Track Scales was appointed in the autumn of 1911. Upon being notified of his appointment, the chairman got in communication with the other members of the committee, and called a meeting at Texarkana, Ark.-Tex., for Dec. 18th. Only Mr. Jack and the chairman attended. The subject was discussed, and a series of questions were framed. After the meeting these questions were typewritten and submitted to the full committee and to others. A revised list was then made, printed and sent out.

Each member of this Association was sent a copy, and it was accompanied by the following circular letter:

Nashville, Ark., January 27, 1912.

Fellow Members:—

We are enclosing to you a list of questions which we hope you will fill out as far as you may be able from your own experience, and forward to the chairman as quickly as possible. These are being sent to each member, and upon the promptness with which you reply will depend the promptness with which we can get out our report.

These questions are largely to draw out the individual views of the members. A later circular will seek to get the official opinions of the roads, so please fill this out at the earliest moment and return.

Don't hesitate to write us a letter giving an account of your scale troubles or conquests. If you have recently installed a track scale, please give cost, giving separately cost of scales from manufacturers and cost of each class of material and cost of each class of labor separately.

As you all know, our work is gratuitous, and is of value as you each help us.

Yours truly.

The committee also sent to the president, general manager or general superintendent of each road with a mileage of 200 miles or more this letter. It was filled out with the name and title of the officer addressed and signed by the chairman of the committee:

Nashville, Ark., January 27, 1912.

Dear Sir:—

As an officer in responsible charge of operation you have no doubt felt the losses your road suffered from defective scales and lack of care in weighing.

Our committee has been appointed to collect data and report on track scales, their installation and maintenance. Will you assist us in collecting data by referring the enclosed blank to the officer in charge of scales on your road, requesting him to fill out all blanks, and to especially make us a full answer to questions 2, 4, 8, 11, 15, 20, 24, 28, 30, 33, 35 and 36, using additional sheet if needed?

We will send him a copy of our report which will be submitted to the convention next October and will be glad of any discussion he may give us. We have no way of learning names of officers charged with care of scales except by applying to the heads of the roads.

Thanking you for your help in this matter, and assuring you our effort will be to make the report complete and reliable, I remain,

Yours truly.

Replies were received from 138 members of the association, many accompanied by letters giving information. Replies were also received from 151 railroad officials, and after follow up letters had been written, from eleven more. Blanks were then sent to personal friends and reports ultimately secured covering all but five of the railroads. The replies are summarized on the following pages and cover all but five roads having over 200 miles of road.

After last year's convention the committee was reconstituted. The chairman began a correspondence with the members, compiled the replies to the circulars, had it type written and sent a copy to each member. On Friday, March 21 a meeting was held of the members of the committee who were in attendance at the Railway Engineering Association convention and the full day was spent in discussing phases of the report.

Following is a revised compilation of the replies which have been received to the set of questions sent out:

Has your road adopted a standard scale? If so, describe it.

25 roads having 477,000 cars say No.
8 roads having 451,000 cars build their own scales.
6 roads having 285,000 cars have their scales built to their plans or specifications.
50 roads having 898,000 cars buy some manufacturer's design.

What length of scale do you advise?

40 ft. platform,	11 roads,	having	350,000 cars.
42 ft. platform,	16 roads,	having	280,000 cars.
46 ft. platform,	22 roads,	having	577,000 cars.
48 ft. platform,	3 roads,	having	43,000 cars.
50 ft. platform,	27 roads,	having	526,000 cars.
52 ft. platform,	7 roads,	having	450,000 cars.
54 ft. platform,	3 roads,	having	40,000 cars.
60 ft. platform,	1 road,	having	12,000 cars.
67 ft. platform,	1 road,	having	24,000 cars.

Ann Arbor:—A 50 ft. scale is the proper length for present length cars, as it divides up the weight better.

A. T. & S. F.:—Eight years ago when we adopted as our standard the 46 ft. track scale there were very few cars with a wheel base of more than 40 ft. Since that time furniture and automobile, and perhaps other cars are all being built with a wheel base ranging from 45 to 46 feet, and we now recommend 50 ft. scales in establishing a standard. We have no idea of changing our standard, having nearly our entire line equipped with 46 ft. scales, and there being in the aggregate comparatively few cars that cannot be weighed on them at one draft, and those that we cannot, we weigh accurately half at a time.

C. R. R. of N. J.:—Our present length of 42 ft. is entirely satisfactory, and would not recommend a greater length than 52 ft.

C. M. & St. P.:—Not less than 40 ft. and not more than 42 ft.

C. R. I. & P.:—Our company has both 40 ft. and 46 ft. scales. Our opinion is that the 46 ft. scale is better, with various advantages over the shorter scale. Dispatch in weighing cars is one advantage. On short scales, extra care must be exercised in spotting a car. Then there are cars that can scarcely be weighed on 40 ft. scales.

D. & R. G.:—We recommend 50 ft. platform so that one end of the car being weighed must be cut loose.

N. Y. C. & H. R.:—Not less than 52 ft. live platform with 6 ft. overhang at each end.

P. R. R.:—Ordinarily, not over 52 ft.

Pa. Lines W.:—An officer says he prefers 52 ft., but the standard is 45 ft.

S. P.:—Our standard scale is 50 ft. 100 tons, 5-section, full capacity on beam, which will take care of 95 per cent of the cars, and for all general purposes has been found to be satisfactory.

How many sections has your standard scale?

4 sections, 41 roads.
5 sections, 28 roads.
6 sections, 10 roads.
4 and 5 sections, 3 roads.
4 and 6 sections, 3 roads.

Would you prefer a different number of sections?

Roads using 4 sections; No, 39, Yes, 2. Roads using 5 sections; No, 27, Yes, 1. Roads using 4 and 5 sections; 2 prefer 4 sections, 1 prefers 5 sections. Roads using 4 and 6 sections; 1 prefers 4 sections, 2 prefer 6 sections.

Give your reasons for preferring this number:

Preferring Four Sections.

Ann Arbor:—Gives less bearings to wear and gets same results.

A. T. & S. F.:—This number decreases cost of scale and complications.

A. C. L.:—Four section scales give good results. Additional sections only increase maintenance and construction cost.

B. & O.:—It consists of only 14 levers up to the beam; the decreased number of levers, pivots and bearings reduces the total amount of friction without materially limiting the strength or life of the scale. The force applied at the load supporting stand (except at the fifth lever, which transfers the load to the scale beam) acts downward on the foundation and is controlled better than when acting upward; the scale is most sensitive; its adjustment is better maintained, and it is easier to repair.

P. & L. E.:—Most practical for our service.

B. & A.:—Simplified construction and better working scale.

B. & M.:—The fewer the levers the less the friction.

C. P.:—To eliminate friction, and economy in repairs.

C. R. R. of N. J.:—A greater number of sections would increase the number of levers and with it greater friction and liability of getting out of level.

C. & O.:—Because less parts to get out of order, and easier to adjust.

C. & N. W.:—Eliminates a lift lever.

C. B. & Q.:—The less bearing points, the greater accuracy.

C. G. W.:—Fewer levers and less chance of going out of alinement.

C. M. & St. P.:—Length of levers not excessive. The fewer sections, the less complicated.

C. R. I. & P.:—More equal division.

C. N. O. & T. P.:—Reduced number of bearings.

Colo. Mid.:—Simpler.

Colo. & Sou.:—By using a short test car can get better test on four sections.

D. & R. G.:—Fewer sections the better. Longer sections expensive.

D. & I. R.:—Simplicity and ease of adjustment.

E. J. & E.:—We have tried more sections. Same failed.

G. T. R.:—Less trouble to keep adjusted.

H. & T. C.:—Fewer sections easier to maintain and give better weights.

I. C.:—Scale with more than four sections is difficult to keep adjusted.

Intercolonial:—All parts in suspension are supported directly from foundation, except fifth lever.

K. C. S.:—Every section adds friction; adds more pivots, as well as more parts for getting out of order.

K. C. T.:—Reduces number of bearings to minimum.

L. S. & M. S.:—Fewer bearings easier to adjust.

L. V.:—To have as little friction as possible.

L. & A.:—Easier to adjust and maintain.

L. & N.:—Simple construction and durable.

M. P.:—Because more sections require more levers and knives, and it is a difficult matter to keep the center line of levers in proper line.

O-W. R. R. & N.:—Less sections, less trouble.

O. S. L.:—Account inaccuracy of greater number.

P. & R.:—Four sections is the nearest perfect of any track scale made.

Pa. Lines W.:—This number is sufficient to keep deflections out of bridge.

P. R. R.:—In 4-section scales all lever thrusts, except one, are tending downward on foundations. This is not true of any scale of more than four sections.

P. R. R.:—The least number of sections, the less to keep up.

St. L. & S. F.:—Less pivots, consequently less friction and easier to repair.

S. A. & A. P.:—Less cost of maintenance.

S. A. L.:—Easier to adjust and maintain.

Southern:—Decreased number of bearing points, less trouble adjusting.

Vandalia:—The more sections the less accurate.

Virginian:—Recommended by Southern Weighing & Inspection Bureau.

Wabash:—Minimum friction and number of parts.

W. & L. E.:—Less levers, less bearings, less trouble to adjust.

Preferring Five Sections.

C. I. & L.:—Simplicity.

C. C. C. & St. L.:—Better division of load. Less load on individual pivots.

E. P. & S. W.:—Gives more strength to levers and bearings.

G. H. & S. A.:—Seems to answer all requirements.

H. V.:—Prevents deflection in stringers and masonry stands up O. K.

K. C. M. & O.:—Are enough for 50 ft. scale.

L. S. & M. S.:—Gives more strength to levers.

L. I. R. R.:—Five sections give satisfactory results.

M. & St. L.:—It is a good proportion up to 50 ft.

M. R. & B. T.:—Five sections have been satisfactory.

N. P.:—A five section scale, built in concrete, does not give us any trouble, as the levers set in perfectly level.

S. P. Co.:—Most convenient.

St. L. S. W.:—This number keeps the scale in better balance and gives better results.

Preferring Six Sections.

D. & H. Co.:—Works out just right according to our ideas.

Erie R. R.:—Proper design.

I. & G. N.:—We get better results than from any other.

N. Y. C. & H. R.:—Makes it possible to use a single I-beam girder and it increases the bearings 50 per cent over a 4-section scale.

P. & L. E.:—Gives more supports to the girder, less load on the pivots, makes all parts lighter for scale of equal length and strength.

S. P. L. A. & S. L.:—Satisfactory.

As many of the objections are erroneous, or based on erroneous assumptions, and as the supposed lack of accuracy of a scale of more than four sections, which is disproved by the service record of the P. & L. E. 6-section scale, the following statement of the case for the four section and the statement for the other side are given:

P. R. R. (A. W. Epright) :—A careful analysis of the lever system on the various types of track scales in use today has determined the fact that those of four section type are superior to those of any other number of sections, for the reason that all parts in suspension are supported directly from the foundation, except the fifth lever, whose thrust is tending upward from the foundation, and when more than four sections are used in a track scale connecting levers must be introduced, which have no multiplying function but simply transmit the motion. These additional levers require additional fulcrum points and contacts, which do not materially prolong the enduring accuracy of the scale, but which introduce friction when wear occurs.

E. P. & S. W. (C. R. Johnson) :—We know that some of the scale companies recommend 4-section scales in preference to those with more than four. This is not on account of any fault with the scale itself, but a scale with more than four sections requires greater skill in the scale inspector to adjust when it is out of adjustment. Where a scale inspector knows his business and is furnished with proper equipment in the way of scale test cars there should be no difference in the results obtained over his 4-section scales and his scales with more than four sections. It is my personal opinion that a man who cannot adjust a 5-section scale should not be turned loose on any scale.

Does your standard use overhang or bridge ends?

Yes, ...32 roads.
No, ...24 roads.

(In framing this question the committee consulted the literature of three scale companies. Two of these used the term "overhang" and one, "bridge ends." We used both).

If so, how much?

A. C. L.; Car. & N. W.; L. & N.; and L. I. say they use it, but do not state how much.

10 in., N. C. & St. L.; P. S. & N. and Vandalia.

14 in., C. of N. J.; D. & M.; G. H. & S. A.; G. T.; L. V.; and M. K. & T.

21 in., C. P.; O-W. R. R. & N.

2 ft., B. & O.; C. & O.; D. & I. R.; K. C. T. and P. R. R.

4 ft., I. & G. N. and Maine Central.

5 ft., B. & M.; C. C. C. & St. L.

6 ft., B. & A.; D. & H.; D. L. & W.; N. Y. C. & H. R.; P. & L. E.; Southern.

One-third distance between first and second bearings, B. & L. E.

What is your standard beam?

2 roads, ... 80-ton
28 roads, ...100-ton
2 roads, ...110-ton
1 road, ...150-ton
32 roads, ...type registering

Have you used suspension iron frame scale?

No, ...71 roads
Yes, ...14 roads

This question seems not to have been clear to all. The title was taken from a scale company catalog, but in some instances seems to have been confused with suspension bearings. The next question should have made it clear.

Under what conditions is it better than a pit scale?

A. T. & S. F.:—Its use is intended in a sandy country, but it cannot be built rigid enough to give good results.

A. C. L.:—At points where no foundation can be secured, or where adequate drainage cannot be provided.

B. & O. C. T.:—In cases of bad drainage, and in winter time levers will not be frozen in snow and ice.

B. & M.:—Where it is impossible to get good drainage.

D. M. & N.:—We use it at coal docks as platform is too near surface of water to allow for pit.

G. H. & S. A.:—Only where no drainage can be obtained.

Me. Cent.:—At tidewater or in swampy ground.

N. Y. C.:—We do not recommend its use; in case of derailment it is apt to be injured.

O-W. R. R. & N.:—Ours has given splendid satisfaction; it is protected from the elements of the weather.

Pa. Lines W.:—The reason a suspension scale is better than a pit scale is because the levers are up in the dry and the pivots and bearings do not rust as fast as a pit scale, and one can always get at the levers and keep them clear.

Vandalia:—This scale is better than a pit scale if it were not for the fact that it obstructs the view of the yard.

What kind of foundation do you prefer to place scales upon?

Concrete, ...78 roads
Reinforced concrete, ...9 roads
Cut stone or concrete, ...3 roads

A. A.:—Our scale foundations are all built of concrete, which I believe is the best material for this purpose.

C. of N. J.:—Concrete, with pile substructure where necessary.

C. M. & St. P.:—Concrete, but use cedar piles in some places where we have a heavy fill of loose dirt, or where ground is boggy.

C. St. P. M. & O.:—Concrete, with piles where necessary.

E. P. & S. W.:—Where the foundation ground is perfect we set the sections direct on concrete piers which are bonded into the side and end walls as well as the base, and where there is any question about the foundation ground being anything but perfect, we put in a very heavy footing and interpose a steel sill under the scale sections.

H. V.:—Concrete or well constructed masonry.

I. C. & S.:—On the very best foundation practicable.

K. C. T.:—On concrete. Concrete to rest on earth if solid enough; if not, piling should be driven.

N. Y. C.:—Concrete. Some places we use grillage and at others piling for foundation supports.

Would you favor the use of timber construction in installing scales under any conditions?

No, ...73 roads
Yes, ...14 roads

If so, state conditions and give reasons.

B. & L. E.:—Only in temporary location of line or grade, as the timbers could be easily removed and used again.

B. & S.:—By using wooden foundation would give bearings a little chance to give and thereby not breaking castings.

D. M. & N.:—For temporary work only.

D. & I. R.:—Only for temporary location.

D. S. S. & A.:—Piling and timber in low wet ground.

F. E. C.:—We use wooden stringers.

H. & T. C.:—In swampy ground.

I. C.:—It has been found that if timbers are installed between the scale and bottom for cushion it keeps the pivots sharp longer than if metal is used.

L. I.:—Timber has given good service.

M. R. & B. T.:—Have timber underframing. Have not yet felt free to change to steel, fearing that rust would be worse than decayed wood.

P. & R.:—When a scale is placed on a trestle, piles are driven for the bottom plate of the trestle to set upon. The trestle is built and braced with great care; each bent is set directly under each section, heavy stringers (12" x 16") run longitudinally and heavy cast iron foundation plates or bottoms weighing 1,300 pounds each cross these stringers for the section to set in.

W. & L. E.:—Only at points where piles must be driven and where concrete would not hold.

Do you advise a scale house?

Yes, ...56 roads
No, ...24 roads

For continuous use only, 2 roads. A variety of designs were submitted; some consisted of roofs over the beam box and others elaborate enough for an office for work and files.

What length of lead track do you advise?

40 ft. straight each side of scales, 4 roads.
45 ft. straight each side of scales, 1 road.
50 ft. straight each side of scales, 7 roads.
60 ft. straight each side of scales, 11 roads.
66 ft. straight each side of scales, 3 roads
70 ft. straight each side of scales, 3 roads.
75 ft. straight each side of scales, 18 roads.
80 ft. straight each side of scales, 1 road.
90 ft. straight each side of scales, 4 roads.
100 ft. straight each side of scales, 2 roads.
105 ft. straight each side of scales, 2 roads.
170 ft. straight each side of scales, 1 road.
¼ mi. straight each side of scales, 1 road.
Length of cut of cars, ... 1 road.

How do you construct approaches to preserve alinement and surface?

None, ...20 roads
Ballast, ...13 roads
Coping timber, ... 2 roads
Wall of concrete, 8 ft., 7 roads; 9 ft., 2 roads; 10 ft., 10 roads; 12 ft., 2 roads; 20 ft., 1 road; bed ties in concrete, 7 roads.

P. & R.:—On the top of the end coping walls we bed and bolt a large ribbed cast iron plate. The rails are secured to these plates by clamps of 1 in. by 3 in. iron, bolted down with 1 in. set bolts, and the base of the rail is slotted to receive a 1 in. set bolt to keep it from creeping. When on a grade a point is used in the permanent rail with the heel of the point next to the scale platform and the permanent rail passing the point on the outside allowing it to creep down 6 or 8 in. or more without obstructing the scale.

Do you make provision for securing water tight deck?

No, ...66 roads
Tight as possible, ...14 roads
Canvas over joints, ... 2 roads
Old carpet over joints, ... 1 road.
Belting over joints, ... 2 roads.

Do you find special difficulties in securing drainage?

Yes, ...28 roads
No, ...49 roads.

Ann Arbor:—At Cadillac, where the country is flat but sandy, we sunk a pit a short distance from the scale and drained into this, allowing the sand to take care of the drainage, and it has worked to our satisfaction.

A. T. & S. F.:—We have rapid drainage wherever it can be obtained: otherwise we have a cesspool 6 ft. deep by 4 ft. square below bottom of pit on the outside of the scale wall under the scale house. We are using standard metal pump on all track scales (made by James B. Clow & Sons) called the Clow Hercules Trench No. 3. A dry pit prolongs the life of all scales, wood or iron. Rust is a greater factor for the destruction of metal parts in a scale than the actual wear. Our motto is "Keep scale pits dry and clean." This can be done by using five ventilators on the platform made of ⅜ in. mesh netting 12 in. x 12 in. square.

B. & O.:—Sometimes, in which case we build a cistern outside of scale pit in which to drain.

B. & L. E. and St. L. & S. W.:—Waterproof scale pits.

L. V. and P. R. R.:—Where a drain is impossible dig a pit alongside and siphon the water out of the scale pit.

P. & R.:—Yes, but we drain.

What width and depth is your standard pit?

6′ 3″ x 4′	Soo Line.
6′ 8″ x 6′	H. V.; St. L. S. W.; W. & L. E.
7′ 0″ x 4′ 0″	Bang. & A.; B. & M.; E. P. & S. W.; F. E. C.; K. C. M. & O.; Q. O. & K. C.; S. A. L.
7′ 0″ x 5′ 0″	B. & S.; C. & S.; D. & M.; N. C. & St. L.; N. P.; O. S. L.; P. S. & N.
7′ 0″ x 6′ 0″	C. G. W.; M. & St. L.; M. R. & B. T.
7′ 2″ x 4′ 6″	Mo. Pac.
7′ 5″ x 5′ 4″	A. T. & S. F.; C. R. I. & P.; E. J. & E.; So. Pac.
7′ 6″ x 4′ 6½″	A. C. L.; C. C. & O.; L. S. & M. S.; S. A. & A. P.
7′ 6″ x 5′ 0″	C. of N. J.; M. K. & T.; N. W. Pac.
7′ 6″ x 6′ 0″	A. A.; Col. M.; D. & R. G.; D. M. & N.; D. S. S. & A.
7′ 6″ x 6′ 6″	K. C. S.; L. & A.
7′ 6″ x 7′ 6″	P. lines W.; S. P. L.; A. & S. L.
8′ 0″ x 3′ 8″	Long Island.
8′ 0″ x 6′ 0″	Can. Pac.; D. & I. R.; Erie; Intercol.; G. T. R.
8′ 9″ x 4′ 6″	C. St. P. M. & O.
9′ 0″ x 6′ 6″	L. V.; Me. C.; P. R. R.; Frisco.
9′ 6″ x 7′ 4″	C. M. & St. P.

What provision do you make for cleaning scale pit?

Trap doors in deck, 76 roads.
Cleaned by section crews monthly, 3; weekly, 3; irregularly, 20.

Would you allow scale on other than a level track?

Yes, ...44 roads
No, ...27 roads

What is steepest permissible gradient?

Per cent	Roads
0.3	2
0.5	7

0.75	1
0.8	3
1.0	10
1.5	2
2.0	10
3.0	3
4.0	1

How often are your scales inspected?

Weekly,	6 roads
Semi-monthly,	5 roads
Monthly,	23 roads
Bi-monthly,	15 roads
Tri-monthly,	22 roads
Semi-annually,	7 roads
Annually,	3 roads
Irregularly,	4 roads

How often are track scales tested?

Weekly,	3 roads
Semi-monthly,	2 roads
Monthly,	10 roads
Bi-monthly,	16 roads
Tri-monthly,	25 roads
3 times a year,	7 roads
2 times a year,	8 roads
Annually,	4 roads
Irregularly,	7 roads

Do you have a standard testing car?

No,	28 roads	175,000 cars
Yes (some type),	52 roads	1,652,300 cars
Yes, old engine tank,	2 roads	11,000 cars
Yes, ore car,	2 roads	13,500 cars
Yes, coal car,	1 road	6,200 cars

Do you repair your own scales?

Yes,	62 roads
No,	21 roads

Have you a special shop for this?

Yes,	24 roads
No,	38 roads

If so, describe it.

A. T. & S. F.:—The Santa Fe system is divided into seven districts, the Coast Lines is District No. 4, and comprises 2,500 miles. We have the scale shop located at San Bernardino. The shop was built for that purpose and is equipped with hoist, a complete sealing apparatus, drill press, emery grinders, forge, etc. All machinery is run by an electric motor. The shop is 20 ft. x 46 ft., ceiled inside and covered on the outside with corrugated iron. We keep in this shop one man to do all scale work, and the district inspector also works at the shop when he is not on the road. The shop is under full charge of the district scale inspector.

A. C. L.:—Tool car specially fitted, which is moved from point to point with test car.

C. of N. J.:—Frame structure about 24 ft. x 30 ft. attached to general blacksmith shop of M. of W. & S. Dept., and is provided with planer, slotting machine, lathes, forges, benches, testing apparatus, tools, etc.

C. of N. J.:—Brick building 25 ft. x 36 ft., plank floor, with concrete sealing, platform in floor, 4 ft. x 6 ft.

C. B. & Q.:—Shop is 30 ft. x 50 ft. and is equipped with grinding wheel, air hoist, and testing bed; also hanger rack for sealing up levers and beam.

C. M. & St. P.:—Fitted for grinding bearings, setting and sealing, testing, etc.

C. R. I. & P.:—A section of the machine shop equipped for such work.

Colo. & Sou.:—Shop equipped with forge, vises, drill presses, sealing frame, etc.

D. & H. Co.:—Just an ordinary work shop, 30 ft. x 40 ft.

D. & R. G.:—Ordinary shop with forge, benches, tools and one sealing beam and bed.

E. P. & S. W.:—Use part of iron working and pump shop.

H. V.:—Shop 20 ft. x 24 ft. with forge, anvil, drill press, vises and work benches.

H. & T. C.:—Shop about 16 ft. x 30 ft. with lathe, drill press, power driven emery grinder, standard test weights and bench tools; also apparatus for sealing scale levers.

Ill. Cent.:—Frame building 32 ft. x 68 ft., fully equipped for building scales.

K. C. S.:—Have car fitted out with tools for scale inspector's use in testing and repairing scales.

L. S. & M. S.:—Use a part of the pump shop.

L. V.:—Have shop for scale work, 24 ft. x 48 ft., fitted up with work bench and vises to fit up levers, also straight edges and gages for this purpose; also standard weights to do all testing and sealing. Machine shop does all machine work, and blacksmith shop all forging and tempering.

Mich. Cent.:—Machine shop in appearance, with all tools necessary.

M. K. & T.:—Building with necessary tools to seal and refit irons.

M. P.:—A scale shop located at Pacific, which is equipped with proper sealing weights, sealing beams and repairs for all scales used on the system.

N. P.:—This shop is equipped with blacksmith tools and bench with vises; a sealing frame and test weights for testing levers.

Pa. Lines W.:—Our shop is located at Allegheny, Pa., and is fitted up with necessary tools for doing the work; also with U. S. standard master weights where scales are sealed.

P. & R.:—Our shop is 25 ft. x 60 ft., well lighted, with a concrete floor covered with hardwood flooring. The test house adjoins with a master scale installed for weighing our test cars before each trip. Our shop is equipped with lathe, planer, reamer, drill press, emery wheels, etc.; also an overhead track for one man to handle any center or end lever or fifth lever easily and quickly. We also have a master even balance beam for testing weights. We have a nest of brass standard test weights that the U. S. Government verified at Washington, D. C. These weights are used two or three times a year to verify the weights the chief scale inspector uses in the shop daily. The nest of weights is never opened except in presence of the chief scale inspector, and the weights are never handled with the bare hand but with forks covered with buckskin.

St. L. & S. F.:—We have three men employed under direction of the mechanical department; the work at present is all done by hand; expect to remodel shop and use machinery.

St. L. S. W.:—Room 30 ft. x 50 ft. with benches.

Sou. Pac.:—20 ft. x 40 ft., one story, fitted with necessary tools.

Have you ever considered building your own scales?

Yes, ...18
No, ...65

Give some account of the reasons for and against.

Roads that Do Not Build Their Own Scales.

B. & O.:—It is not thought to be economical, and many good features of scales are patented.

C. & N. W.:—No reason given.

C. M. & St. P.:—The saving, if any, does not seem to justify it.

C. R. I. & P.:—More ready supply of repairs.

D. & H.:—Decided not to build, as we have a factory located on our line.

H. & T. C.:—Think we could make them cheaper and better. Beams would have to be bought.

I. & G. N.:—Can build cheaper than we can buy them.

M. C.:—Uniformity, cheaper and less delay.

St. L. & S. F.:—It requires considerable help to handle a shop for building scales; also competent men. We do not consider we would save any money.

Virginian:—Cheaper and better.

Those Who Build Their Own Scales.

C. R. R. of N. J.:—We do it cheaper and get a better scale.

I. C. R. R.:—We are building our own scales, and have done so since 1888. Have found it economical to do so.

L. V. R. R.:—We can build scales cheaper than to purchase them; also have a uniformity of scales and have parts to make repairs in case of breakdown, without calling on scale manufacturers.

M. P. Ry. Sys.:—Because they can be built cheaper at our own shop and all repairs are cheaper.

P. R. R.:—It is more convenient and cheaper.

P. Lines W.:—The cost is less and better work.

P. & R.:—By building our own scales we can have a uniform and interchangeable scale. We are not afraid to use metal as our aim is to get beyond deflection. If we do this and our levers, etc., are built on proper lines good results are sure to follow and in case of a break-down the scale is soon in service again by the use of a duplicate part.

Vandalia:—We can make them about 50 per cent cheaper than we can buy them.

What is your mode of sealing levers after repairing?

Ann Arbor:—By steel template. Of location of pivots and knife edges.

A. T. & S. F.:—We hang one end of a lever on the sealing beam, the other end is placed in stationary stand while U. S. standard weights are put on center pivots figuring the poundage to the beam, taking into consideration the multiplication of the beam.

A. C. L.:—After repairing and adjusting, levers are confined by set screws.

B. & O.:—By the use of weights and beams.

B. & L. E.:—Do not seal (Do,—Erie, F. E. C. and O-W. R. R. & N.).

B. & S.:—By set screws.

Car. & N. W.:—Do not seal.

C. R. R. of N. J.:—Levers are sealed after repairing by suspending, balancing and testing as per multiplication.

C. & N. W.:—A special frame for each kind of lever; lever sealed to standard multiplication.

C. B. & Q.:—All levers are sealed by standard weights.

C. G. W.:—Have each lever separately in shop and adjust.

C. R. I. & P.:—Sealing beam.

C. C. C. & St. L.:—Is usually returned to manufacturer for this work.

D. M. & N.:—Done by state scale inspector, and not supposed to be broken by anyone else.

Soo Line:—Done by state scale inspector, and not supposed to be broken by anyone else.

E. P. & S. W.:—By testing and adjusting until correct.

H. & T. C.:—Fit pivots as accurately as possible by measurement, then swing beam on testing table and test and seal off with weights known to be absolutely accurate. Grinding pivots and knife edges until beam balances with weights to give proper multiplication.

I. C. R. R.:—Regular way in scale shop by use of sealing weights.

I. & G. N.:—Test each lever to correct multiple with test weights.

L. S. & M. S.:—Test weights. Work out to gage. Adjust nose irons until correct.

L. V. R. R.:—Each lever separately. Levers after repaired are set up separately and sealed or tested to its multiple, and when the whole scale is assembled it does not matter at what point certain levers are placed.

M. C. R. R.:—Sealing beams.

M. & St. L.:—We use the Neill patent.

M. K. & T.:—By using sealing iron testing weights.

M. P. Ry.:—All sealing of levers is done by a regular expert scale repairman located at the scale repair shop, and no levers are sent out until sealed by him.

N. C. & St. L.:—Even balance levers with sealed test weights. Offset levers with small scales and weights.

Mo. Pac.:—Each lever is placed in the sealing frame and tested before installed in the scale.

O. S. L.:—Each lever sealed to its multiple at three graduated weights.

P. R. R.:—See illustrations.

Pa. Lines West:—We have sealing racks to seal levers.

St. L. & S. F.:—Levers are sealed with an 800-lb. weight and standard test weights.

St. L. S. W.:—Have test beam in shop.

Southern:—Cold chisel mark at proper multiple point on arms of the levers.

Vandalia:—With test weights.

P. & R.—All track scale levers are sealed or proven separately, and all handled as a first class lever, therefore only using the one lever to get the movement. In building our shop and the test house great care was used to eliminate vibration and by setting up a lever to seal with the use of vibrating balls a lever can be brought to a very sensitive action, in fact to an action that could not be obtained when several levers are connected together. All track, wagon, depot and portable scale beams are proven separately and each notch proven.

Have you used a self-registering device?

Yes, ...34 roads.
No, ...23 roads.
Using type registering device, ...25 roads.

If so, do you recommend for general use?

As to self-registering, Yes, 0; No, 34.
As to type registering, Yes, 19; No, 4.

If not for general, do you recommend for special use?

As to self-registering, Yes, 29; No, 4.

If not for general, do you recommend for special use?

A. T. & S. F.:—We would not recommend it for any use, but on track scale where there is speed required it will work, but in all cases the device is expensive and accuracy is sacrificed for speed.

A. C. L.:—Occasionally in large yards for accurate and expeditious handling. The Streeter-Amet is the only device we have used.

B. & O.:—Where a registry of the weight is necessary it is very desirable.

B. & A.:—Where much weighing is to be done.

B. & L. E.:—Where sufficient cars are weighed to justify its use.

C. & O.:—Where the amount of weighing is sufficient to justify.

C. & N. W.:—We use the Streeter-Amet device for weighing cars in transit.

C. B. & Q.:—We use the Streeter-Amet device on hump yards and wherever cars are weighed in motion.

C. M. & St. P.:—We use the Streeter-Amet device. We recommend it for rapid weighing for low class freight where perfect accuracy is not essential.

C. R. I. & P.:—We have used only the Streeter-Amet. We recommend it where speed is required.

C. N. O. & T. P.:—We recommend it where weighing is very heavy. Have used but one device.

C. C. C. & St. L.:—We have used only the Streeter-Amet. We recommend it for busy yards where cars are run over a hump and weighed in motion.

D. & I. R.:—Near iron ore mines we use 36 ft. scales with 6 ft. overhang, making 24 ft. platform with deep foundation pit and solid deck, supported on steel rails, using Streeter-Amet device. Would recommend this device only for weighing solid trains of cars of about the same length and all carrying the same commodity, as coal or ore. That, furthermore, the track conditions should be favorable, allowing trains to pass over the scales at a uniform low speed of about four miles per hour, with very little tractive effort from the locomotive, and that effort as uniform as possible.

D. M. & N.:—All our iron ore is weighed while train is in motion, weighing at the rate of about three cars per minute, and weight is automatically recorded on a tape. We use the Streeter-Amet, and have used no other.

D. S. S. & A.:—We use Streeter-Amet device, and recommend for weighing moving cars.

G. H. & S. A.:—Have used several and threw them away.

G. N.:—We recommend for use at ore docks or stockyards for fast work.

H. V.:—Yes, have used the Streeter-Amet device. Is necessary where fast weighing is required and gravity is accessible. Cars are pushed over hump and cut off and cars singly are allowed to pass slowly over scales and near leaving end an automatic trip starts weight recorder.

K. C. S.:—Yes, for ore or coal mines where a separate track on a light grade to allow cars to run over scale slowly, one at a time.

L. S. & M. S.:—Yes, for weighing ore or grain.

M. & St. L.:—We have used but one. I do not believe practicable in winter unless in house.

N. Y. C.:—Have used but one device. We recommend for continuous motion weighing.

N. P.:—Streeter-Amet is the only one we have used. Am hardly prepared to recommend a registering device for general use.

P. R. R.:—The best one that we know of is the Streeter-Amet weighing and recording device. It is the only one we have ever tried out on track scales. We do not recommend for general use.

Pa. Lines W.:—We recommend the Streeter-Amet device for special use. We are using them at very busy weighing points. Would advise using it in

gravity when scale is on grade. We use it in general service where rough freight is handled.

P. & L. E.:—We use the Streeter-Amet device on our scales at Glassport where it has been in use four and one half years. We can at any time spot weigh a string of cars by use of the beam, and afterwards weigh the cars running at a speed of five or six miles per hour, using the device, and have the same weight recorded. All weights are automatically stamped on the way-bill, making it impossible for weighmaster to estimate and supply weight in such cases without showing on the cards that this has been done.

S. A. L.:—We have used but one type. We recommend its use in yards where trains of cars are weighed daily.

Southern:—We have used only the Streeter-Amet. We recommend its use for hump scales or for constant service wherever required.

W. & L. E.:—We have five Streeter-Amet weighing and recording devices. We do not recommend for general use, but do for busy scales. We are using on scales in dock and terminal yards.

Have you any steel beams? How do you keep them bright?

B. & S.:—With pumice stone.
C. & N. W.:—Lacquer the beam.
C. M. & St. P.:—Rub with pumice stone.
Col. Mid.:—No trouble in this dry climate.
D. &. R. G.:—No definite instructions.
D. M. & N.:—By constant and occasional wiping.
D. S. S. & A.:—U. S. metallic polish.
Erie:—Clean them.
G. H. & S. A.:—Depend on weighmaster.
K. C. T.:—Of steel, plated. Being plated does not rust.
N. P.:—All our beams are of steel, nickel plated. They require little care.
P. R. R.:—The beams are painted and the gloss rubbed off, so as not to reflect the light.
Pa. Lines W.:—Do not keep bright. Have them japanned with white enameled figures.
Virginian:—Polish with emery dust and oil.
W. & L. E.:—Paint what parts we can. Balance polish and oil.

What treatment do you advise for steel for pivots and pivot bearings?

None,	61 roads.
Painted,	9 roads.
Well cleaned,	2 roads.
Dry clean, no oil,	2 roads.
Cleaned and oiled,	8 roads.
Graphite,	3 roads.
Potash, Plumbago & B. & B. each,	1 road.

A. T. & S. F.:—We advise no treatment, but good quality of steel. We are using "Silver Steel" 26c per lb.; it is cheapest in the long run.
A. C. L.:—Case hardening of best workmanship.
B. & O.:—Use scale pivot steel and temper it.
B. & L. E.:—Manufacturers' specifications. (Call for silico-manganese steel.)
C. P. R.:—Composite steel pivots, copper plated.
C. & N. W.:—Temper to medium hardness.
E. P. & S. W.:—Grinding to keep sharp and renewals.
Erie:—Case hardened. (M. K. & T., S. A. & A. P., Va.)
H. & T. C.:—Think we get best results by fitting pivots when soft, then case hardening and finally grinding for perfect.
L. V.:—Use good crucible steel. Endeavor to have working edge of

pivot hard and back soft; bearing to be made harder than pivot, and when in scale, keep as dry as possible, clean and well painted.

M. P.:—Properly tempered before sending out and covering with coat of oil in pit.

P. R. R.:—It would take a volume to answer this question. (C. W. R.) This is a trade secret. (B. B. G.) We get the best steel on the market for pivots and pivot bearings, and fit them up very carefully to gage and harden the steel without cracking, and if it is sprung we grind it up on an emery wheel.

P. & R.:—Use the best steel. Work with a low heat. Use great care in tempering.

Southern:—Tool steel process.

A. Bousfield, Chief Engineer, E. & T. Fairbanks & Co.:—Replying to yours of the 23rd, the quality of steel used in pivots and pivot bearings has an important relation to the allowable load per lineal inch of contact surface. When pivots and bearings are arranged so as to preserve a full line of contact at all times and are of sufficient strength to prevent an undue deflection, loads of 10,000 lbs. per lineal inch of contact surface are permissible. Steel with a carbon content of from 0.90 per cent to 1.00 per cent is preferable for that portion of the pivots and bearings which are in contact. Commercial steels are being manufactured which have a layer of high grade steel at the contact edge, while the remainder of the structure is composed of soft steel or iron. This composition is ideal for pivots and bearings because the contact surface can be hardened to a high degree while the remaining portion remains soft and ductile. It is possible to treat high grade uniform steel so as to render the contact surfaces very hard and still preserve a degree of ductility in the remaining portion. A skillful workman is, however, necessary to produce this effect but in any case the results are not so reliable as when composite steel is used. The price of either the high carbon steel or the composite steel is considerably higher than for steel of a lower carbon content, so that if either grade of steel were specified for a scale it would necessitate an increase in the cost of manufacture.

In a paper descriptive of the scale of the P. R. R. read at the Sixth Annual Conference on Weights and Measures, Mr. Epright stated that all the knife edges and bearing planes and corresponding contact points in this scale are made of vanadium steel, it being claimed for this steel that it is less susceptible to corrosion and wear, and that consequently it will give longer life to and preserve the sensibility of the scale.

The Carnegie Steel Co. build their own scales, and they are a good scale, and while they are large makers of steel, some of it being used for scale pivots they use for their pivots Crescent Steel, made by the Crucible Steel Co. The names "Crescent" and "Silver" are high grade steels made by different mills of the Crucible Steel Co. I do not know which is better, and think the elements are concealed, as the steels are sold by their trade names.

Does it injure a scale to allow engines to run over scale rail?

Yes, ...57 roads.

A. T. & S. F.:—Yes, it is the worst kind of abuse to scale bearings.

B. & O.:—Depends on capacity of scale.

Bangor & A.:—No more than any other wheel load if speed is not excessive.

B. & L. E.:—Yes, when hauling a load.

Car. & N. W.—Not the scale we use.

C. B. & Q.:—Yes, where engine weight exceeds capacity of scale.

C. M. & St. P.:—It depends on size of scale bearings or capacity of scale and weight of engine.

Colo. Mid.:—Yes, if done indiscriminately.

D. & M.:—Not at slow rate of speed.

D. M. & N.:—Not if carefully handled.

D. & I. R.:—Yes, to some extent.
G. H. & S. A.:—Most decidedly yes. Consider this the cause of more scale trouble than all other.
G. T. Sys.:—Yes, if at excessive speed.
Intercolonial:—Do not approve of it.
K. C. M. & O.:—Yes, account of thrust and jar.
O-W. R. R. & N.:—Yes, under their own power.
Pa. Lines W.:—It does not do the scales any good.
Southern:—Very materially.
Vandalia:—It helps wear it out.
W. & L. E.:—Yes, for heavy engines and all engines without pony trucks.

Does your road tolerate the practice?

No, ...62 roads.
Yes, ... 5 roads.

B. & O.:—In some cases, where scale is of ample capacity.
B. & M.:—Every endeavor is used to prevent it.
C. & N. W.:—Some instances in large yards.
D. & I. R.:—Only in special cases.
G. H. & S. A.:—Not when we know it.
H. V. R. R.:—Only where no dead rail.
H. & T. C.:—Practice forbidden.
Int.:—Instructions are not to do this.
K. C. T.:—No, under no conditions.
Maine Cent.:—It is necessary at times.
M. R. & B. T.:—Not any more than can be helped.
M. K. & T.:—Not permitted but sometimes practiced.

What means do you take to prevent it?

Signs, ... 3 roads.
Discipline, ...19 roads.
Report for Disc. ..... 1 road.
Instructions, ...13 roads.

A. T. & S. F.:—We lock our switches with Yale locks at both ends and weighmaster locks and unlocks them when cars are weighed.
C. & N. W.:—All available means.
F. E. C.:—Use pocket track with rules to keep engines off.
Int.:—Not when it can be avoided.
M. R. & B. T.:—Be on good terms with the Supt. and he can usually reduce to a minimum.
N. C. & St. L.:—Thirty to sixty days' lay-off.
N. Y. C.:—Constant watchfulness on the part of those responsible for the proper use of the scale, especially the weighmaster. Also by posting instructions on the scale houses forbidding the practice.
O. S. L.:—Dismissal from service.
P. R. R.:—We have adopted a relieving gear, controlled by the weighmaster in the scale office.

General Notes.

M. R. & B. T.:—We do not claim our methods to be best and latest practice. Our scales are the standard 42-ft. 100-ton scale. We carry an extra scale in stock which we keep in order to replace when any need repair. To have these parts interchangeable we have not made any changes in the past five or six years and probably will not until an entire change may be necessary. So far these scales have given little trouble, and maintenance cost has not been excessive.

R. C. Burkholder (Streeter-Amet W. & R. Co.):—Track conditions is a volume by itself and is the cause of fully one-half the trouble experienced with scales, as well as exerting a large influence on the life of the scale. We have had a wide experience throughout all parts of the country in weighing conditions generally. Scales are being built and installed at the present time which give satisfactory results. As summarizing, we might say that any scale will give satisfactory results in motion weighing which is sufficiently heavy to prevent the transmission of the excess vibration to the beam; which is built on a rigid concrete foundation without the use of wood in construction unless it be the coping or decking, and in which the construction and design are such that the levers (particularly the fifth lever) cannot swing with the motion of the car.

A. T. & S. F.:—Where possible to secure it, drainage is provided for, but in rock, or where distance is too great, a pump is installed. Pit is of concrete masonry, water proofed. Bottom is sloped to carry the water to a small sump under the scale house. This is drained by a sewer or taken care of by a No. 3 Hercules trench pump, Clow L 1436. Floor of scale is waterproofed with heavy ducking over all openings, painted to make waterproof. Trapdoors admit to the scale pit for purposes of inspection. Small pieces of stack netting are placed in the floor at intervals for ventilation.

C. C. C. & St. L.:—A word should be said about the alleged capacity of track scales as furnished by the manufacturers. It is well known that these capacities are misleading, for the reason that they are based on a uniformly distributed load, while the actual loads brought on a track scale by a car are concentrated on the different bearings, and the length of the pivot bearings and strength of the levers should be figured for the greatest load which can come upon a section, rather than for a uniform fractional part of the total load on the scale. The importance of the length of pivot bearings on the main lever should be emphasized. We use a scale with 8-in. pivot bearings, but I am satisfied that it will be necessary to use longer ones, either 10 or 12 in., to reduce the maintenance cost on scales under heavy modern traffic.

E. P. & S. W.—Where there is enough weighing to occupy all the time of a weighman, we put up a house. Where scale is near a freight house and one of the clerks is assigned to do the weighing, we put up a canopy to protect him and his records.

T. B. Turnbull, Ann Arbor R. R.:—Our scale foundations are built of concrete, which I believe is the best material for this purpose. We have no particular trouble with drainage except at Cadillac, where the country is flat, but sandy. We sunk a pit a short distance from the scale and drained into this, allowing the sand to take care of the drainage and it has worked to our satisfaction. In regard to timber construction in installing scales, I presume by this you mean the entire timber work for bearing pieces and stringers. I would advise that should we install any more scales they would be of entire steel construction, although at present all of our scales except one are on timbers. We do our own general repairs. When a scale needs a general overhauling we send it to the maker. The only length of lead I care for is to have from 45 to 50 ft. of straight track off the scale so a car can be entirely squared before it strikes the scale. We have never made any provision for a water tight deck, but have provided for snow by covering the space between the floor and wall with old belting. For a test car we use an abandoned engine tank filled with scrap iron, which will weigh approximately 60,000 lbs. We also carry on this car about 4,000 lbs. of 50 lb. weights. We endeavor to test our scales once in every two months, putting our test car on a very accurate scale at Toledo before starting out so as to get the exact weight and then test and adjust all our scales to this weight.

C. R. Johnson, E. P. & S. W.:—We have adopted no standard scale as standard for general use. We make no objection to scales of four, five or six sections, in fact we have some of eight sections, where it is necessary to weigh a car empty under a coal tipple and keep the car on the scale while it is being loaded and slowly moved under the loading chute. For scales in

freight yards where ordinary commercial freight is handled we use a 50 ft. scale of five sections, set on a concrete foundation. Where there is any question about the foundation ground being faulty we put in a very heavy footing and interpose a steel sill under the scale sections. Where the foundation ground is perfect we set the sections directly on concrete piers which are bonded into the side and end walls as well as the base. We use pits five ft. deep and seven ft. wide for these scales.

D. Burke, S. P. Co.:—The standard scale of the So. Pac. lines is a 50 ft., five section, 100-ton scale, full capacity on beam. It is being installed according to a plan devised by the scale inspector of the Southern district. It is of concrete, using piles where necessary. The drainage sometimes makes necessary a cess pool to secure perfect work. It has been our purpose to work to a common standard to do away with the necessity for carrying various parts in stock. Scales are tested regularly semi-annually with the test car which is sealed at 30,000 lbs. When this test is made a representative of the Transcontinental Freight Bureau accompanies the scale inspector. A detailed report of findings is furnished all concerned. From time to time the scales are given a special test, depending on their actions and condition. At the time the test is made the scale and pit are given a cleaning, and any defects showing up are remedied. It is important that scales be given close attention in the way of the platform being kept clean to prevent dirt and debris, rocks, etc., falling into the mechanism and interfering with the operation. Close watch should be kept to see that rails do not bind, thus interfering with the operation of the scales. Whenever the scales are out of order it should be the duty of the agent or operator to notify the superintendent and scale inspector. A stitch in time often saves nine. The scale inspector has a shop at headquarters with an assistant where the heavier repairs are made. He also has a shop car equipped with tools and repair parts, which he uses when going over his territory.

C. H. Eggers, C. R. I. & P.:—We have a scale department with general and division inspectors who are under the direct supervision of the scale department. The B. & B. forces do practically all the work in connection with the installation of new scales, under the direct supervision of the district scale inspector, also all heavy repair work, but whenever possible the scale inspector is required to be present.

G. H. Soles, P. & L. E.:—We are now constructing two new 200-ton track scales at McKee's Rocks, and arranging to erect one at Dickerson's Run and one at Jacob's Creek which we expect to complete this year. These are the same style scales that we erected at Glassport, Pa., in May, 1908, which has been in constant use ever since that time and has weighed an average of 10,000 cars per month without any repairs. It is tested once a month with a 60,000 lb. test car and it has been found to be correct on each test. No adjustment has had to be made since the installation of the scale. We test our track scales once each month. When we are going over the road testing our track scales we test individual track scales along the line when requested to do so by the owners. In case we find them in need of repairs we notify the owner and they look after the repair of their own scales. We have several 120-ton six-section scales 56 ft. long in use on our road which are giving good results, but when we find it necessary to reconstruct them, we are renewing them with the 200-ton scale.

Organization of a Scale Department.

It seemed that it might add to the interest of the paper to have some data as to how the various roads handle their scale department, and the following letter was addressed to over twenty leading roads:

"As a matter of interest, we should be obliged to you if you would outline to us the method of handling scale work on your road. Start with the vice president, or other officer who approves plans and expenditures and follow the line down to the men who do the actual work of installing, inspecting and maintaining, stating from whom each receives his orders and what he does."

In response to this letter we received replies from six roads.

A. T. & S. F. (F. C. Maegley) :—The installation and maintenance of all scales and weighing on the Santa Fe system lines, over 10,000 miles, comes under the supervision of this office. Expenditures for new scales are passed on by the vice president in charge of operation. Requisitions for scale repair work are made by our district scale inspectors, and approved by superintendent or general superintendent, on whose division the work is performed.

Our principal scale shop, with chief scale inspector in charge, is located at Topeka, Kans., and the chief scale inspector has supervision over all scale matters on the system, and he as well as his subordinates, reports to this office, but are carried on the pay rolls of the mechanical department.

We have a thoroughly equipped scale shop at Topeka, where all heavy repair work is performed, and our master scale, on which our test cars are weighed in and out, is located there.

The chief scale inspector has a foreman and several helpers, an office and a stenographer for conducting his correspondence. We have two steel constructed, short wheel base (6 ft.) test cars weighing 31,500 lbs. each. Each car is in charge of a scale expert and with the two we aim to test every track scale on the system about three times a year. In addition to this, district scale inspectors make tests with loaded cars once each one or two months, according to the necessity, and the agent at each track scale station is required to make loaded car test once each week and report to the district scale inspector. These district scale inspectors report directly to the chief scale inspector and this office, although they are carried on the mechanical department pay roll. They supervise all scale work that is done by the B. & B. Dept. men, who report to the superintendents in performing that work, or the district scale inspectors may call on section men to assist them in any way they can, cleaning out scale pits, etc.

We have our more than 10,000 miles of lines divided into six scale districts, with a scale inspector in charge of each, and who is held responsible for the condition of all scales on his district.

The California district is equipped with a scale shop and the district scale inspector has a helper who does light repair work on track scales, and much on small scales. We have a smaller shop, with a helper, on the Texas lines, and also a small shop on the Colorado district, but do little repair work there.

We have in connection with the scale shop, an additional man—scale inspector—whose especial duty is to standardize the weights of warehouse trucks, which is, of course, a very important feature in connection with the weighing of L. C. L. freight on flush platform scales.

C. & N. W. :—We have a regular scale organization that covers the entire North Western system, in charge of a chief scale inspector who reports to and receives his instructions from the engineer of maintenance. It is his duty to inspect, examine, test and look after all track scales, including stock, wagon, baggage, freight house and portable. He also keeps a record of all scales, the date they were installed and makes report from time to time as to their condition. When a scale has reached a point where it can no longer be economically maintained and it becomes necessary to renew or charge out, it is handled on his recommendations. We go over our entire list of scales the first of each year and make up a list of such scales that can be repaired or must be renewed. This list is submitted to the general manager, who in turn makes his recommendations to the vice president. If the list is approved as submitted, then the general manager calls upon the engineer of maintenance to prepare situation plan and detailed estimate, this estimate and plan being worked up by our division engineer, the location of scale being decided upon and situation plan approved by the division superintendent. When this has been settled, the proposition then comes to the engineer of maintenance, who in turn submits to general manager for formal authority to proceed with the work.

The scale renewals and repairs are under the jurisdiction of our chief

scale inspector, he being furnished such assistance as may be required to install a new scale or reset an old, by the division engineer; these are masons for foundation, and B. & B. for installation.

I. C. R. R.:—The scale department organization of this road consists of—
Supervisor of scales (1), who reports to engineer M. of W.
Scale inspectors (2), who report to supervisor of scales.
Scalemen (1), who reports to supervisor of scales.
Scale carpenters (3), who report to the supervisor of scales.

The scale shop is under charge of supervisor of scales and consists of scale machinist, helper, blacksmith and helper. The engineer maintenance of way reports to the chief engineer.

N. P. Ry.:—The organization consists of two practical scale experts. Each man has approximately 45 track scales to inspect and keep in repair. In addition to this we do some inspection of private scales located on our line, where we accept the weights. We have two test cars with a short wheel base weighing approximately 104,000 lbs. These cars are loaded with steel rail and then covered to protect them from the weather. In addition to the test cars we have two tool cars or work shops equipped with the necessary tools for making ordinary repairs. Each car carries a number of extra parts for emergency use. When there is any heavy work to be done we call on the operating department and they furnish men from the bridge gangs.

Our test cars are constantly in service. As fast as possible we are taking out timber foundations and substituting concrete. The men in charge of our test cars are sufficiently experienced to rebuild an entire scale if necessary.

They report direct to this department, presumably for the reason that the accounting department are charged with the proper collection of revenue, and we have a number of inspectors on the road who devote a large portion of their time to checking both carload and less than carload weights, and it was thought that this work of inspecting the track scales could be made to dovetail in very nicely with the other work. We have one chief inspector of weights who devotes his entire time to this work and spends practically all of his time on the road and keeps in pretty close touch with the work that is being done by the scale inspectors. One inspector has his headquarters at Tacoma, the other at St. Paul. The Tacoma man wires his daily tie-up to this office and also notifies the superintendents at Tacoma so that if he is wanted in an emergency he can be located without delay. We have been working along these lines for a little over two years and have made considerable headway and we hope to do even better in the near future.

P. R. R.:—The purchase of scales is authorized by the general manager; plans are approved by the general superintendent of motive power, and the work of installation, maintenance and inspection is done by the motive power department of the various systems under the respective superintendents of motive power.

C. R. I. & P.:—This department reports to the second vice president in all system matters, and to the general manager with reference to matters pertaining to their respective districts. I enclose herewith copy of our organization circular from which you will note that we have five regular scale inspectors, who handle all work on scales in the field. All work on foundations is done by the maintenance of way department under supervision of the scale inspector of the district. When scale inspectors desire assistance on scale work they communicate with the superintendent of the division, who instructs the maintenance forces under his jurisdiction.

APPENDIX B.

STANDARD TRACK SCALES OF THE PENNSYLVANIA R. R.

By A. W. Epright.

(From report of Sixth Annual Conference on Weights and Measures held at the Bureau of Standards, Washington, D. C., February, 1911.)

Railway service requires continuously accurate scales, but at present there are very few companies which have a thorough system for maintenance and for making the proper tests and corrections, and it is a regrettable fact, speaking generally, that many track scales are never tested and are always believed to be correct until decayed and condemned as being unsafe in the roadbed.

The Pennsylvania Railroad seems to have been the pioneer, in this country at least, in establishing an efficient scale organization, and as most of the other companies who have gone into the subject have adopted, in most part, the plan of supervision as outlined by this company, we thought it advisable to present our methods of construction, test, and maintenance of railroad track scales.

A careful analysis of the lever systems of track scales in use today has established the fact that those of the 4-section type are superior to those of any greater number of sections. For this reason the Pennsylvania Railroad Co. has adopted as their standard a 4-section, 52-foot track scale having a capacity of 300,000 pounds and embodying the most modern ideas of scale construction; the features of which will be considered in detail.

In this type of scale the wooden substructure has been eliminated; in fact, no wood whatever is used on the scale proper except in the ties supporting the rail columns. These ties are placed on the platform to absorb the shock caused by the wheels of the car when they first strike the platform and to protect the scale in case of derailment.

With the old type of track scale generally in service the overhanging portion of the platform has an opportunity to tip, as when the first pair of wheels strike the platform the other end is caused to rise, and as the movement proceeds an accelerated, powerful return occurs. The intensity of this force is very destructive to all parts of the scale. In the new type of scale the "overhang" has been eliminated, which reduces the destructive effect of the entering car to a minimum.

The lever system has been scientifically worked out and 100 per cent allowed for impact and live load, so that the stresses are entirely within the margin of safety established by experience. Heretofore practically no consideration has been given to this point by the manufacturers of this type of scale.

The surface of the platform is supported independently from the scale mechanism. This form of construction renders the scale immune from the effects of wind pressure, rain, snow, or ice on the platform.

The suspension bearings, introducing what is known as the "Cradle principle" in this scale, differ materially from the rigid type of bearings formerly used in that they get rid of the movements of the knife edges across the faces of the hardened steel bearing planes when oscillations of the platform occur. This design also provides greater freedom of action and greatly reduces the dependence put upon the check rods to

retain the platform in its proper position. The design of this bearing is intended to preserve the accuracy of the scale, and the various details have been worked out with a view of specially adapting it to the relieving gear.

In designing the knife-edges a maximum load of 4,000 pounds was set for each linear inch of contact, whereas in most of the older types each inch of knife-edge was under a maximum load, which in some cases amounted to as much as 10,000 pounds.

Notwithstanding the fact that the weight of the levers has in some instances been increased three or four times, the sensibility has not been materially affected. This is due in a measure to the fact that more machine work is being done on the scale, and it is also partly due to the fact that a more uniform distribution of the load in the lever system is obtained.

All the knife-edges and bearing planes and corresponding contact points in this scale are made of vanadium steel, it being claimed for this steel that it is less susceptible to corrosion and wear and that consequently it will give longer life to and preserve the sensibility of the scale.

The independent alignment of each individual lever has been made possible by an improved connection of the levers. Leveling pads are also provided on all levers with faces machined, so that in all adjustments the original plane of the knife-edges is preserved.

The scale is provided with a full capacity beam reading to 300,000 pounds and is equipped with a poise operating on specially designed ball bearings, which reduces the frictional resistance of the poise to motion from about four pounds to about three or four ounces.

The large weight of the movable poise causes a slight displacement of it to correspond to a relatively large weight on the platform. This makes it imperative to have the teeth cut accurately in the beam and to have the latch engaging in the teeth to seat accurately at all times. This proper seating is secured by the design of spring and latch provided, one of the features of which is the spring and its adjustment, which enables a firm pressure on the latch to be maintained.

Probably the most radical departure from the old form of construction is the introduction of the relieving gear. This takes the place of the rigid dead-rail system with its cumbersome supporting columns that fill the vault practically full of metal and prevent proper inspection, operation, and maintenance of the bearings and other parts of the scale. All the metal parts of this scale present easy access for inspection, cleaning, adjustments, or renewals.

The fundamental parts of the relieving gear consist of a series of eight toggle jacks supported in pairs by universal bed plates. These jacks are operated by a torsion shaft with suitable link connections at each of the four sections. The shaft is in turn operated by a double-ended cylinder controlled by the weighmaster in the scale office, the controlling power in a few cases being water, but air has been found to be preferable.

When it is desired to make a dead rail out of the scale rail the weighmaster operates a four-way controlling valve causing the toggle jacks to be operated so that the vertical pistons (or plungers) travel upward against the I-beams forming the metal bridge. This action raises the platform from the suspension links and takes the weights off the knife edges without causing them to be disturbed, so that the operation of the relieving gear (which is done in about one-half second's time) is accomplished without disturbing the contacts of the knife edges on the bearing planes, which preserves the alignment of the lever system.

When the jacks are operated, making a dead track out of the scale track, semaphore arms at either end of the scale platform are automatically actuated, indicating that the dead rail is set for the use of engines.

The total weight of the platform is about 38,000 pounds, and, with 80 pounds per square inch in the cylinder, the bridge can be raised so that an H-6 engine, loaded, imposing a maximum load of about 283,000 pounds, will not show any weight on the beam when going over the scale. It is of course impossible to work the operating gear under a superimposed load, but this is not necessary, as the average interval between cuts of a car is about eighteen seconds, and the relieving gear can be operated in this time.

It is desirable to provide simple and effective means by which with a minimum of attendance and skill, the cars may be passed rapidly and without stopping over the platform of the scale with the proper velocity to permit each car to be weighed as it passes, regardless of the usual variations in the length of successive cars.

To accomplish this the track over which cars pass to the platform is provided with an elevation or hump, the height and distance being so proportioned that when cars are pushed at a uniform rate up one side of the hump (being uncoupled from each other before or while being pushed up the hump) each car will pass over the top and run down the other side and so on to the scale platform with the proper velocity to be accurately weighed.

The design of the hump is such that the elevation of its apex above the scale platform can be adjusted. In winter when everything is taut the apex of the hump should be somewhat higher than in summer when cars form less rigid structures. In winter the lubricant also becomes stiff, affecting the free running of the cars.

With reference to yards at which necessity demands that loaded cars should be weighed and empty cars classified over the same hump a compromise may be made in its height.

For rapid and accurate weighing it is desirable to have the scale platform and adjacent side of the hump as short as possible, and in practice it has been found advisable to make this side of the hump about equal to the distance between the centers of the wheel trucks of the cars having the shortest wheel base.

It is a matter of common knowledge that cars passing over a railway track scale located at the head of a classification yard are not of one pattern, and the distances between the front and rear wheels vary.

The time in which a moving car may be weighed is that elapsing from the moment the rear wheels pass on to the scale platform to the instant the front wheels pass off, and in order to keep this time down to a desired minimum, cars having a short wheel base should move more rapidly across the scale platform than cars having a longer wheel base.

With the advent of the hump the effect of this variation in the wheel-base length is in a measure automatically compensated for. Other things being equal, when the side of the hump adjacent to the scale platform is short, as it should be, the velocity acquired by the cars running down the side of the hump varies inversely with the length of the wheel base of the car.

Standard plans have been carefully worked out which not only provide for the electric lighting of the vault under the scale but also for the scale office inside and the vicinity of the scale outside. This insures the proper grading of light for night weighing. A standard bay-window front in the scale office is also provided which gives an unobstructed view for the weighmaster in both directions. The designs also include plans for the artificial heating of the vault during winter months, the temperature being controlled automatically.

* * * * * *

To insure results and in order that the work may conform to the United States standard of mass, the Pennsylvania Railroad Co. has in

its possession a set of master weights, which at intervals are returned to Washington to be verified and have their values corrected if necessary. The last time these weights were returned for verification the 50-pound master weight was out less than 1 part in 350,000, or less than 1 grain in 50 pounds.

When the master weights have been verified and returned from Washington, the values of our working or shop standards are derived by comparison with the master weights on a specially constructed balance of high sensibility, the sensibility being less than 2 grains in 4,000 ounces.

After the shop weights are made to conform with the master weights, our 50,000 pounds of 50-pound test weights are checked and resealed, this work being done on a shop balance which has a sensibility of about 2 parts in 350,000, and the practice has been to seal these weights as close as the balance will weigh.

After the values of the 50-pound test weights referred to above have been corrected, they are used to try out the master scale upon which the test cars are proved.

This master scale was specially designed for the purpose by the Pennsylvania Railroad Co. and is of all-steel construction, with a capacity of 120,000 pounds. Under a load of 50,000 pounds, the weight of our heaviest test car, it shows a sensibility of about 1 pound.

After the regular test-weight cars are "proved" on the master scale, they are placed in charge of a competent scale inspector and started on their various routes covering the entire system.

Special instructions have been issued that no work of any nature whatever shall be done on the cars in transit unless the scale inspector is present and then only such repairs are made en route as will eliminate any possible element of danger. We have found these precautions necessary to insure the value of the weight of the test car at all times, and by this system the actual variations of the cars between trips can soon be ascertained and a compromise made if necessary.

The various test-weight cars ordinarily require from six to eight weeks to make a complete circuit, after which they are returned to the master scale at Altoona for correction, if it should be necessary. While admittedly an unusual record, we will say that a car has been known to make as many as seven trips, aggregating as much as 10,000 miles, without varying more than 10 pounds in weight, notwithstanding the fact that a great deal of this travel was made during the winter months.

When the cars are returned for test they are examined and any repairs needed are made. The boxes are sponged, etc., so that little, if any, work will be required on the trip.

As in other callings of life, in the construction and testing of railroad track scales ability is required, the importance of which fact is appreciated by some railroads, while others are apparently indifferent to it.

The design of our regular test-weight car, known as the class "YB" car, is superior in every way to the type of test-weight car formerly used and is now being copied by most railroads. The car is specially low and squatty, with the wheels projecting up into the casting which forms the body of the car. There is no shifting load inside to change the center of gravity; however, there is a pocket for carrying 100 pounds of 50-pound test weights, which are neatly fitted into place, and there is a small receptacle to retain the extra weight made necessary by the fluctuation in the weight of the car (See Fig. 74).

The underside of the car is provided with snow shields and is entirely free from projections which can collect material picked up by the whirl when traveling at a high speed and which would necessarily change the weight of the car.

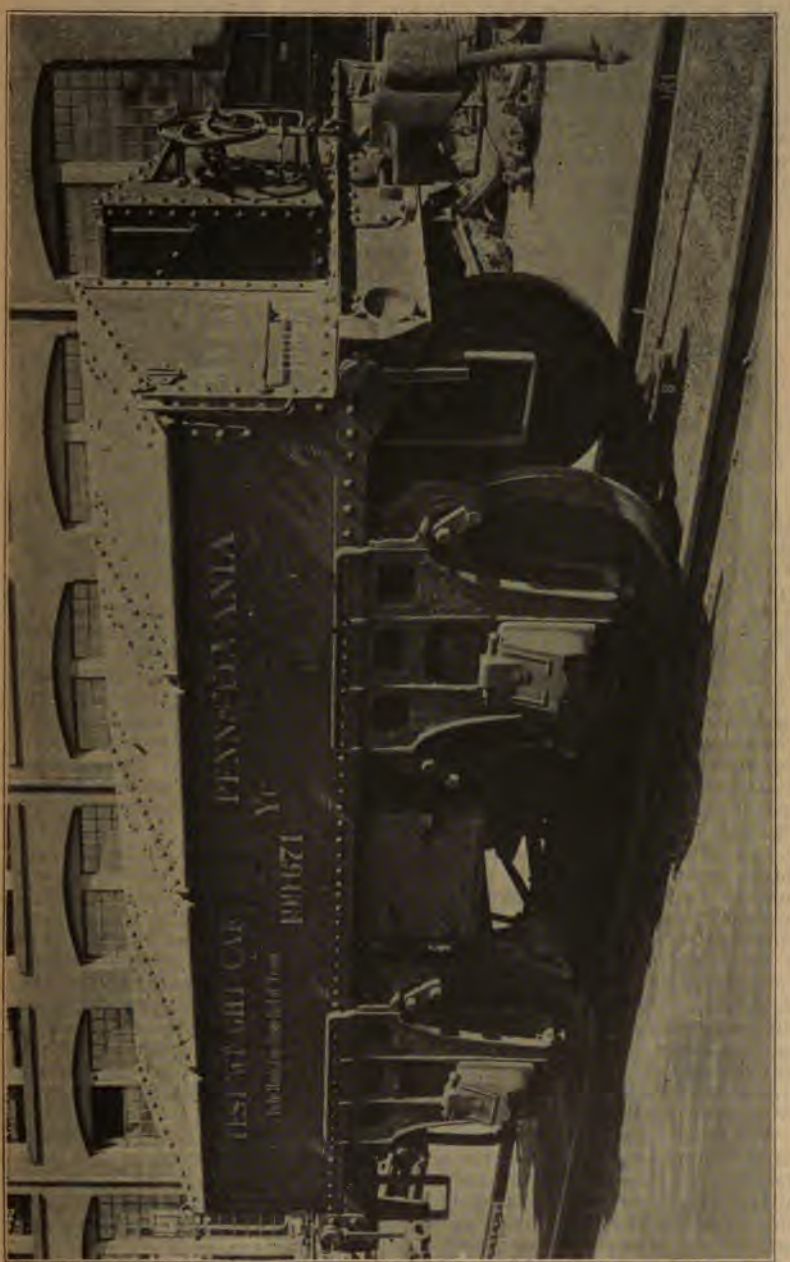


Fig. 84.—Pennsylvania R. R. Test Car Y-C.

In addition to this car which is used in regular service, we have a special design of test-weight car for carrying 50-pound weights for testing wagon scales or stockyard scales up to their full capacity. The construction consists of eight compartments, four on each side of a central passageway running the length of the car, each compartment holding 5,000 pounds of a 50-pound test weights, or a total of 40,000 pounds. The weight of the car alone is about 20,000 pounds and with the test weights makes a total of 60,000 pounds for the combination. As the wheel base is suitable for a four-section 46-foot track scale, the car is often sent out as a heavy test-weight car for testing the regular track scales (shown in Fig. 84).

APPENDIX C.

SIMPLE EVOLUTION OF WEIGHING DEVICES.

(Read before the Engineer's Society of Pennsylvania May 20, 1912.)

By Dr. F. Reichmann.

(Superintendent of weights and measures of the State of New York.)

Weight is the force of gravitation exerted on a certain mass. The mass is invariable and may be defined as the amount of material in a body. To determine weight we may use any physical relation in which the expression of force occurs. Starting with any equation in physics involving the element or factor of force and where the other elements can be determined it is a comparatively simple matter to design an instrument to measure such force which then can be used to counterbalance the weight. There may thus be designed weighing machines of most diverse kinds. Those in ordinary commercial use, however, make use of only two of the better known physical principles, first, the principle of equilibrium of forces acting on a body, which means that in order to have equilibrium the sum of the moments of all the forces about an axis must be zero. Second, Hooks law—ut tensio sic vis. The first of these is used in all lever scales and the latter in all spring scales. These two fundamental principles are the underlying basis of practically all weighing devices now in use.

Let us apply the above principles. To construct a simple balance, a beam is supported at the center and at either end of the beam are hung the two masses whose weights are to be compared, one of which is usually a standard of known mass. In order to arrive at any degree of precision we immediately have to take into consideration the fact that the forces do not act at given points and that the beam of the balance is not weightless nor is it free from bending. We substitute for the points, knife edges, which have to be carefully adjusted so that the three knife edges are co-planar and are parallel. We have to place them so upon the beam that the center of mass of the beam falls just below the point of support, because if it falls above the point of support the system is in unstable equilibrium and if it falls just at the point of support it is a neutral equilibrium.

We must then consider the sensitiveness of the balance as to whether it is sufficiently sensitive for the work to be performed and in this consideration we have to determine what loads are going to be compared and so design our beam that it is as light as possible yet rigid as possible. The sensitiveness will be increased in direct proportion to the length of the beam. As the length of the beam increases the time of vibration also increases, and it would be highly inefficient to use the long period of vibration of a long beam, though the long armed balances have

been used not only to increase the sensitiveness but also to cover up faults of construction because any error in the adjustment of the knife edges is necessarily less appreciable in a long armed balance than in a short armed balance. It becomes necessary then to strike an average between what is desired for the period of the balancing and the sensitiveness and so adjust the length of the beam that it will satisfy these conditions.

There are other and important considerations relative to the method of supporting the beam and also the methods of hanging the pans on the beam which are important for weighings of refinement, also, you must take into consideration the construction of the balance case itself and the placing of the balance when weighings are made. It might be said in passing that most balance cases in use are improperly made because the beam is entirely too near the top of the case which with a light beam means variations due to the thermal and air currents set up within the case itself. There should be a large clear space above the beam. It may also be remarked that most American catalogues of balances are so inaccurate in their specifications as to the sensitiveness of the balance that it is impossible to purchase them intelligently. The sensitiveness not being stated in intelligible and consistent terms even in the same catalogue of the maker. The accuracy of the balance is simply a question of refinement in mechanical construction and it may be remarked that the art of making fine balances has been highly developed within the last quarter of a century; in fact, has been developed to such an extent that the accuracy of the balance is far in excess of the accuracy and the stability of the standards of weight themselves. Future progress will have to be first in the construction of more stable weights.

There has been no great advance in the construction of spring scales for refined or accurate weighings of a high degree of accuracy, the only exception being that of a spring scale in which the bending of the quartz fibre is measured by a micrometer microscope. Spring scales are not ordinarily used for a high degree of scientific work.

Passing from the brief consideration of even arm balances, it is a simple matter to use a balance of a beam of unequal arms, the two ends of the beam bearing a certain definite ratio to each other. In fact, such balances were used for commercial purposes up to the beginning of the last century and it was only at the middle of the last century that a combination of levers was used for the purpose of increasing the multiplying power of the weighing machine. One of the first designs of such was made by Erastus Fairbanks, where two unequal arm simple levers were combined, the long arm of the first lever being linked to the short arm of the second lever and thus the power of the machine considerably increased. This method can be indefinitely extended and is used today on all weighing devices of a large capacity. Here again many considerations have to be taken into account. First, it is convenient to have a platform of considerable area so that loads can be conveniently drawn thereon. This necessitates the platform being placed above the levers instead of being hung from the levers. For small capacity scales the most direct method is that of having knife edges cast onto the levers, these resting on bearings on the frame, were used upon the pivots holding the platform. The platform by means of loose rods was prevented from sliding over such pivots. This in a crude manner did very effective work after the cast edges were replaced by hardened steel pivots and the cast iron bearings were replaced by polished steel bearings. This type of scale is in use today even for very large capacity scales. The size of the levers was simply gauged by guess work by some pattern maker. It has only been in the last decade that real engineering thought has been applied to the design of multiple lever scales, and today we have for instance such scales as the railroad track scales of the Pennsylvania Railroad which was a distinct advance from previously designed scales of

large capacity. The principal advantages are that the material in the lever is correctly proportioned in relation to the stress and strain encountered and that pivots bear their entire length and are of sufficient size to take care of the load imposed upon them and that all bearings are suspension bearings and thereby are giving the necessary flexibility. Of particular interest to the engineer in the matter of weighing devices is where he is called upon to install a scale and establish specifications therefor and for guidance in such matters I wish to emphasize these points:

1st. Your specification should state the capacity of the scale.

2nd. It should state the minimum graduation on the beam or the minimum reading if it is a dial scale.

3rd. Specification should definitely state the sensitiveness at full load.

4th. It should specify that all pivots should bear their entire length.

5th. It should specify that there should be no deflection in the levers at full load.

6th. It should specify a stable foundation.

These are essentials aside from the material and size of platform and method of erecting. No scale should be accepted until it has been tested to full capacity.

I have in mind three pages of specifications on scales which were embodied in the specifications of a public contract and after all statements relative to the size of platform, kind of wood on the platform, the maximum tensile strength of the members to be used in the construction of the scale, the color of the paint to be used thereon had been mentioned, there was absolutely no statement as to the capacity, the sensitiveness, the stability or the accuracy; in short, under the three pages of specifications it was not essential to have a weighing device which could weigh.

The engineer of today should not be interested only in scientific or technical mechanics. Unfortunately many still are not interested in the broader phase of engineering, which involves the economic aspect of the industrial proposition which they are called upon to consider. In this broader aspect the engineer must consider what the weighing device is called upon to do and must consider that the demand of today requires that weighing devices, as the indicator of the quantity delivered, must be accurate and permanent, rapid and if possible automatic. To illustrate, there recently came to my attention a case of an industrial concern which had a two ton scale which had been installed in a receiving room for weighing ordinary iron castings. This scale was graduated to 5 lbs. and sensitive to 5 lbs. The scale was built for that sensitiveness and no more. Later it developed that the scale was conveniently placed for the purpose of weighing copper and it was determined to have the scale read to quarter pounds. The engineer of the firm thought it was sufficient to order a new beam for the scale graduated to quarter pounds, and it took considerable demonstration to convince him that the whole scale would have to be replaced and all the parts in accordance with such required sensitiveness and accuracy. Another illustration of where the engineer often overlooks the matter of weighing was brought to my attention sometime ago in a public highway contract where the specifications called for the weight of a certain amount of surface dressing to cover a certain number of square yards of road. The scale that was used was on insufficient foundations, very inaccurate, resulting in a loss of 8 per cent. in the weight of the surface dressing delivered, which would necessarily impair the quality of the road because an insufficient quantity would have had to cover a certain number of square yards. It might be mentioned in passing that the measurement of the square yards was also very liberal, so that the amount which ostensibly complied with the specifications was used to cover actually about 1¼ square yards, which

amounted therefore to a double defrauding of the builder of the public highway.

In conclusion, the engineer should always consider well, from the standpoint of specifications, the quantity delivered, and any design of an industrial plant should make provision for weighing and measuring devices for checking the commodities received. In specifying such devices he should be very careful to specify those that can perform within reasonable limits, expeditiously and economically, the work which they are supposed to do.

APPENDIX D.

THE MISSOURI PACIFIC RAILWAY COMPANY.

St. Louis, Iron Mountain & Southern Railway Company.

General Instructions for the Maintenance of Scales.

Duties of Employes:—In order to keep the scales in proper condition each employe must thoroughly understand his duties in respect to them.

Supervision of Scales:—The supervisor of scales reports to and receives his instructions from the chief engineer. He has full supervision of all scales and scale work on the entire system, including installation of new scales and all maintenance and standards, or anything pertaining to scales.

Scale Inspectors:—The scale inspectors report to and receive their instructions from the supervisor of scales. It is their duty to make regular inspections and tests of all scales and report their conditions as found to the division authorities, who will arrange for immediate repairs. They will assist the division authorities in installing or rebuilding of scales, or any other scale work when called upon.

All testing is done by the scale inspectors. Division authorities will furnish them any necessary assistance when called upon. They will do any special scale work which is assigned to them by the supervisor of scales. They will make a weekly report to the supervisor of scales of scale conditions as found and reported to the division authorities.

Roadmaster:—It is the duty of the roadmaster to so instruct the section foremen that they may fully understand their duties in regard to maintaining scales according to the general instructions and to see that the section foremen properly carry out these instructions.

Section Foreman:—The section foreman must keep the rails and approaches in proper condition at all times. He must keep the scale cleaned and furnish assistance to the scale carpenter at any time he may be called upon to do so.

Scale Carpenter:—The scale carpenter must make regular inspection at least once every month of all the scales in his territory and see that they are in good condition. He must make all light repairs and know that the section foreman is properly performing his duty in regard to scales.

When making inspection he must observe whether or not the scale is in proper balance and he must see that the beam is being properly cleaned by the weighmaster or person in charge of weighing. Also, he must see that the beam box is kept locked when not in use. He must see

that the decking and rails do not bind and that the scale and approach rails are in good line. All levers and bearings must be closely examined to see that they do not bind and that all bearings are in their proper place. Bolts must be kept tight at all times. He must see that no bolts are touching which would cause false bearing. Check rods must not be too tight. If water stands in the pit and he is unable to remedy the matter himself he must report it to his superior officer at once who will take prompt and proper steps for its removal. He must make sure that no levers or bearings are broken and that nothing is interfering with the steelyard rod which would cause the scale to work improperly, also that all timbers are sound and in good condition. The scale carpenter will furnish the supervisor of scales at St. Louis a monthly report of all scale work done by him.

Track Scales.

General Instructions.

All scales must have good drainage in order to keep the scale bearings from corroding and timbers from decaying.

Beam boxes must be supplied with standard scale locks and kept locked when not in use. All weighmasters will be furnished with keys.

Engines must not run over the live rail of the scale. Enginemen must not use sand in going over the scale.

Switches must be set for the dead rail at all times when the scale is not in actual use.

The practice of throwing switches between two trucks of a car allowing one pair to go over the live rail and the other pair over the dead rail is very detrimental to the scale and is liable to cause a derailment and must not be allowed.

Tracks approaching scales should be on the same grade with the scale for at least one car length each way.

All ties must be well tamped. All ties must be 9 ft. long as per standard plans.

The rail on the scale platform should never be lower than that on the approach. Where this condition exists the deck must be raised.

No rails shorter than 25 ft. shall be used on the approaches to the scales.

Scale rails and approach rails should be anchored to avoid creeping.

The space between the scale rails and approach rails should be not less than ½ in. and not more than 1½ in.

The decking must have at least ½ in. clearance on all sides.

Section foreman must keep the top of the scales cleaned.

All scale pits must be cleaned at least once a month by section forces under the direction of the scale inspector or scale carpenter, and all points where the drainage is insufficient they must be cleaned more frequently.

No dirt or debris of any kind should be allowed to remain on the bottom of the pit, on top of the timbers or on the walls of the pit.

All scale pits and beam boxes should be well ventilated to keep the metal from sweating.

Scale beams must be kept clean by the weighmaster, where such person is employed, otherwise by the scale carpenter.

Regular inspection must be made by the scale carpenter of all track scales at least once every month.

All levers and rods must be thoroughly inspected to see that they do not bind.

No adjustment should be made of any of the scale levers by the scale carpenter. These adjustments will be made when necessary by the scale inspector at the time he goes over the system with the scale test car.

No track scale may be installed or overhauled unless all material

is on hand and a scale inspector is on the ground to supervise the work, the chief engineer to be advised several days in advance.

Old track scales taken out to be replaced with new scales must be sent to Pacific scale shop where proper credit will be allowed.

All scale work must be done in accordance with the standard plans which will be furnished by the chief engineer on request.

Stock, Wagon and Depot Scales.

All beam boxes must be kept closed when not in use.

Scales must never be balanced by placing stones or other objects on top of the counterpoise.

Racks and gates enclosing stock scales must be kept in good condition.

Decking must have at least ½ in. clearance on all sides.

All scales must be frequently examined by the scale carpenter and any imperfections found promptly corrected. If the defects are more serious than he is able to correct he should promptly report the matter to his superior.

Dirt must not be allowed to accumulate in the pit or on the decking. Scale beams must be kept clean by the scale carpenter.

Water must not be allowed to accumulate in the pit. All pits must be drained properly and drain kept clear.

Portable Scales.

All portable scales must be kept under cover when not in use.

Portable scales when out of order must be sent to the general storeroom at Pacific, Mo., for repairs.

APPENDIX E.

THE WEIGHING OF CARS.

By D. J. McGrath, Minnesota State Weighing Department.

(From Scale Expert's Journal.)

Proper lighting of scale and scale house, day and night:

This, in my opinion, is one of the most important features connected with the weighing of cars, in order to insure correct results. I have personally weighed cars at night, with a small lantern on my arm that would not throw a ray of bright light over four or five feet. On dark nights, in order to get correct results, I would have to walk to both ends of the scale to see if the car was properly spotted. A weighmaster, as a rule, has enough to contend with without being handicapped with improper lighting conditions. I am inclined to think if this matter was laid before the officials of the various railroads, they could readily be induced to equip their scales with the necessary lights.

On all cars that are misweighed because of a part of one truck being off the live rail of the scale, an undercharge for freight will result, for which the carriers are never reimbursed. On the other hand, if an overcharge results because of the fact that a part of an adjoining car bears on the live rail of the scale, there is immediately a claim put in by the shipper and if the case is proven, a refund is made. There must be taken into consideration the expense to the carrier made necessary by investigation of these claims.

In my opinion, a model lighting condition for a track scale is a 32-candle power electric light, with reflector, stationed on a post about seven feet high, at each end of the scale; also a 16-candle power drop light hanging over the scale beam. Under these conditions, a weighmaster can readily

see when a car is properly spotted and greatly expedite the weighing of same, thereby reducing considerably the expense to the carriers, who pay large salaries to men in the train service for the performance of this work. Three electric lights of this description would not possibly cost a carrier over $12 a year, and you can readily see where this amount could be lost by the misweighing of any one car, where the freight rate is $1.00 or over per 100 lbs. Scales that are equipped with a scale-house, having an angle or bay window front, a cluster of three or four lights, reflecting toward the ends of the scale, make a very good arrangement; in fact, one 32-candle power electric light helps wonderfully.

For weighing in the daytime, where scales are equipped with houses, there should be a window in each angle and on the full length of the house in front of the scale beam. This manner of lighting greatly expedites the weighing, for in a great many cases a weighmaster will have to run outside of the scale house to get the stencil, capacity or number from car, if scale house is not provided with the proper arrangement of windows. I notice that some of the railroads are building scale houses with square corners and putting no windows in front and are placing them on the ends, near the rear corners. This is a very poor type of construction and handicaps a weighmaster more than if they had no scale house at all. When the railroads can be made to feel the great importance of properly lighting their track scales, I am sure that it will work greatly to their benefit. It will eliminate a great deal of complaint by the shippers and do away with undercharges that result from erroneous weighing.

Regular weighers versus switchmen and train crews:

I do not think the time is far distant, when the railroads will take steps to entirely eliminate all weighing done by switchmen and train crews. In the first place, the great majority of these men think that this is not a part of their duties and consequently do not take any great amount of interest in it. It is a well known fact that it is quite a task to get these men to cut the cars when a regular man is weighing, therefore it is reasonable to assume that where this work is left entirely to them, it is performed without a great deal of care or accuracy. During the last few years, the Western Weighing Association has made a determined effort to do away with all weighing done by switchmen, and it is now only performed by trainmen where a small number of cars are weighed. I have seen switchmen, where a scale was equipped with a recording beam, arbitrarily or for convenience neglect to use tickets that would take a record of the weight and use instead a switch list or some piece of scrap paper to take the weights on. If weighing is done in this manner, where the figures are only shown on the beam in multiples of five, it is a very easy matter to misread them. I find that switchmen are not only careless in weighing cars, but they often lose or misplace the original record of the weights taken, and they are then taken to account at the minimum weight, often causing a serious loss in revenue to the carrier.

Cars coupled and uncoupled at one or both ends:

This has been a much debated question, and there seems to be a great difference of opinion as to whether it affects the weighing of a car to any appreciable extent. Personally, I do not think it makes a great deal of difference where cars are cut at one end, if the track is perfectly level; however, in case of an unusual coupler condition that would form a bind, the variation is liable to be several hundred pounds. The matter of cutting cars is far more serious on scales that have a gravity track, one or both ends, for in this case there will be a binding condition in the knuckle which is liable to produce a serious variation. I have personally recorded differences of seven and nine hundred pounds on cars cut at both and one end, on scales of this kind. A still more serious condition arises on cars not cut at either end, on a gravity scale, as it can be readily seen that there would be a pull downwards at both ends, causing the car scaled to weigh heavy. Of course the pull would vary considerable on scales with various grades.

In my opinion there is only one method to weigh a car correctly, and that is cutting it free at both ends and have the car standing still. When cars are weighed in this manner it eliminates all binding conditions and acts as a constant guide to both weighmaster and switchman to do their work with more care. Furthermore, if any question arises as to the correct weight on a car, a weigher can always stand by his scale result and feel that he has faithfully performed his duty, whereas if he weighs cars cut only at one end or none, there is always that chance of an erroneous weight.

When cars are not cut at both ends, it has been my experience to note that weighmasters grow careless and do not watch to see that the car is properly spotted, and sometimes weigh a car with wheels bearing on the land rail or vice versa, with the adjoining car bearing on the live scale rail. On a great many occasions, switchmen, weighmasters and others have tried to show, by weighing one car, that it did not make any difference whether they were cut or not. I would always ask them to weigh 25 or 30 cars for a fair trial and then they would be always sure to strike at least one car with an abnormal knuckle, which would cause a serious discrepancy in weight, even on a scale with level approach rails.

Means of record,—type recording versus plain beam:

The type recording beam is in my belief the model equipment for a track scale. It not only eliminates all chances of misreading the beam and transposing the figures in taking a record of weights, but in case of a question arising as to the original weight, there is some permanent record to refer to. On scales having a plain beam you are always more or less in doubt as to whether your weight is correct or not.

I have come in contact with scales where the beam was so rusty and the figures so defaced, that it was almost impossible for a weigher to take a correct reading from them. The carriers and other industries that use track scales are adopting the recording beam very rapidly, and I think it will be only a matter of a short time, when they will be in general use on all wagon scales. There is almost as much necessity for the use of a recording beam on a wagon scale as on a track scale, as in a great many places, where the beams are more or less exposed to the weather, they get rusty, and then it is a very easy matter to misread them.

Continued encouragement should be given to weighmasters to use the greatest care in weighing, as a great many commodities are invoiced on the result of track scale weights, and the interested parties are seldom present to witness the weighing. On commodities of this kind the weighmaster acts as an arbiter of justice between the buyer and seller, and for that reason if none other should use the greatest of care in the performance of his duties.

Scale experts for the various carriers may pride themselves on having fine, modern weighing machines, built on concrete and steel; but if the conditions surrounding their scales are not model or as near to it as they can make them, they will always be troubled more or less with erroneous weighing. Scalemen should continuously keep this matter in mind and bring all possible pressure to bear on interested parties to the end: That the conditions surrounding all scales be made as near model as possible.

Weather conditions affecting weighing:

I have noticed from time to time, in check-weighing cars, after a heavy rain, that the result would be materially changed, and have on one occasion recorded a difference of 1,600 pounds on a loaded car. I have on a number of other occasions, recorded variations of 700 pounds to 1,000 pounds. This matter should be given serious consideration on all cars weighed, after a prolonged rain, where discrepancies of this kind occur. I am satisfied that after a long, dry spell, cars, according to their size and age, will dry out anywhere from 100 pounds to 1,000 pounds. On the other hand, cars with leaky roofs, etc., especially when under loads of coal or lumber, will absorb an immense amount of rain, possibly anywhere from 500 pounds to 1,200 pounds. Of course, these discrepancies would not be so liable to occur on new or freshly painted cars.

APPENDIX F.

TRACK SCALES SPECIFICATIONS AND RULES.

Approved by The American Railway Association.

Subject to such changes as may be required to meet Local or Special Conditions. May 21, 1913.

The following recommendations are made with the view of setting an ultimate standard to which railroads generally may work but are not intended to condemn scales, methods of installation or reinstallations, etc., now in service which respond to tests as prescribed in Section 12.

These specifications and rules are not intended to cover installations for special weighing, such as twin loads, etc.

SELECTION, INSTALLATION AND LOCATION OF NEW SCALES.

1. When selecting track scales, the following should be considered:

(a) Maximum loads to be moved over scale for weighing or otherwise, considering the concentration of weight on axles.

(b) Length of wheel base of cars or other equipment to be weighed.

(c) Whether cars are to be weighed spotted or in motion.

2. When track scales are to be installed, consideration should be given to:

(a) Location with respect to yard work and grade;

(b) Character of foundations;

(c) Method of installation;

(d) Drainage, lighting, heating, ventilation.

3. Having the above information, the three essentials of a track scale are:

Design, capacity and length.

4. Scale Design:

(a) Scales should be so designed that the load is suspended from (and not superimposed on) the main supporting levers, unless intermediate means are provided between the platform supports and the bearings to absorb the oscillations and prevent the displacement of the bearings at points of contact on the knife edges.

(b) They should be constructed in four sections with vital parts as accessible for cleaning and inspection as practicable.

(c) Practical means of adjustment should be provided to secure uniform distribution of load on scale at points of support.

(d) Parts of the same type of scale should be of uniform dimensions and interchangeable as far as practicable.

(e) Scale design which contemplates the use of check rods should be checked longitudinally and transversely, preferably at point of least resistance.

(f) Beams should be so designed as to weigh all loads on main and fractional bars without use of hanger weights. The main bar of beam should have not more than six (6) notches to the inch, assuming each notch to represent 1,000 pounds. Fractional bar should be graduated to 50-pound subdivisions, with not more than four subdivisions to the inch, which would correspond to 200 pounds per inch.

(g) Multiplication at butt of beam should not exceed 800 to 1.

(h) Type registering beams should be used where spot weighing is performed.

(i) Sensibility should be defined as the added weight necessary to break and turn the beam from a horizontal position in the middle of the trig loop

to a position at the top of the loop. The play of the beam should be obtained by dividing the total play up and down the trig loop by the distance between the trig loop and the fulcrum pivot. For railroad track scales the angular movement or play should be 2%, and the sensibility should correspond to 1% angular movement of the beam.

The sensibility of a track scale should never be greater than 100 pounds, and when the scale is new should be not greater than 50 pounds; that is, a load of 50 pounds, when applied to the scale platform, should cause the beam to move from a position in the middle of the trig loop to the top of the loop. For verification purposes when new, a scale should be capable of adjustment to within 1-2000 (one-half pound to the thousand pounds) of the capacity, and should be considered inaccurate after it cannot be maintained in adjustment to within four pounds to the thousand pounds, in excess or recess.

(j) Bearings wherever practicable, should be compensating to insure full length contact of pivots with bearings.

(k) Friction in all parts of the suspension should be reduced to a minimum by providing hardened Steel Contacts, and the design of scales should contemplate this important factor.

5. Capacity:

In determining the sustaining capacity of the scale, there is still a diversity of opinion among the best scale engineers as to the better method of procedure, and it is true that in figuring the scale levers the prime factor is to figure for deflection, which may necessitate deviating from standard engineering practices somewhat. It matters not if we assume a very small fibre stress neglecting the impact or assume a higher fibre stress and add a percentage for impact.

As a basis of calculation from an analytical point of view it seems quite natural to first assume the capacity of the scale and then proportion the amount beyond that which will apparently eliminate deflections, and we here approach what may be determined an undeveloped state in the higher art of scale building at this time.

One of the most logical ways of arriving at a conclusion would be to take the maximum weight on a pair of wheels (whether they be cars or locomotives), which at present is about 65,000 pounds, located on a transverse center line of main levers, plus the weight of platform, divided by the number of supporting knife edges. The above may be expressed in the shape of a formula, as follows:

w = Dead Load of Platform.
a = Maximum Weight on a pair of Wheels.
n = Number of supporting knife edges,

$$\text{or maximum load} = q = \frac{w + a}{n}$$

This load "q," which is applied to both main levers of each section at the points of load support, is distributed as follows:

(1) Main Levers. Maximum load "q" at point of load support.

(2) End Extension Levers. A percentage of "q" based on the multiplication of the main lever.

(3) Middle Extension Levers. A percentage of "q" based on the multiplication of the main lever and the reaction of the end extension lever.

(4) Fifth Lever. The combined reaction from the two middle extension levers.

By taking these loads at their respective points of application, the moments can be determined and the size of cross-section computed according to the stresses recommended.

Levers. The design of levers, and the classes under which they appear, should be governed by the use of such sections, that under the load or weight determined from the capacity, the deflections and stresses are within the limits specified.

Stress: Cast Iron, tension, ...2,500 lbs. per sq. in.
Compression, ...5,000 lbs. per sq. in.
" Cast Steel, tension, ...8,000 lbs. per sq. in.
Compression, ...16,000 lbs. per sq. in.
Deflection:
Cast Iron, ...020"
Cast Steel, ...040"

Loops. All loops should be so designed that the respective strengths are equal to those of the pivots, the latter being the basis for calculation. The combined stress in tension due to flexure plus direct tension should not exceed 16,000 pounds per square inch.

Pivots. All knife edges, pivots, and bearing surfaces for same should be made from a steel which possesses such properties as will insure a maximum toughness combined with the necessary degree of hardness to insure minimum wear under maximum loads. The following physical properties based on steel with the internal strains relieved by drawing after hardening, should be as follows:

Ultimate Tensile Strength, ...200,000 lbs. per sq. in.
Elastic Limit, ...165,000 lbs. per sq. in.
Elongation in 2" 5%
Reduction in area, ...25%
Minimum Working Stress, ...20,000 lbs. per sq. in.

Application of load and methods to be followed in determining the cross-section, based on the stress specified:

The lever arm to be used in determining the Bending Moment should equal the horizontal distance from the center line of one loop bearing surface to the other plus a constant (C) minus the total width of boss or sustaining member enveloping pivot divided by 2, plus ¼". Expressed by means of a formula, we would have:

l = lever are required.
L = distance between center lines of loop bearing surfaces.
W = width of boss or sustaining member enveloping pivot.
C = constant and is the distance between the friction face of loop and face of boss enveloping pivot.

Therefore:

$$l = \left(\frac{L}{2} + C\right) - W + \tfrac{1}{4}".$$

Pressure per lineal inch of knife edge. The bearing value per lineal inch of knife edge should be divided into classes: (1) for overhanging pivots from which loads are supported by means of loops; (2) reinforced pivots, or pivots that are backed up along their entire length and are used mainly for fulcrums. The maximum load to be used in the former should be 3,500 pounds per lineal inch. The load to be used in the latter can be as much as 7,000 pounds per lineal inch. For the vibratory beam, the load per lineal inch can be as low as 200 pounds. Between these extremes intermediate calculations can be made.

Structural steel used in connection with the installation of scales shall be properly braced, including diagonal stays, if necessary, and should conform to the specifications for material and workmanship for steel structures furnished by the American Railway Engineering Association.

6. Length:

(a) The length of scales should be considered as the distance between ends of scale rail.

(b) The ends of scale rails should not project beyond knife edges of the end main levers.

(c) When cars are to be weighed spotted, scale should be of sufficient length to place the entire car on the scale and preferably longer to facilitate spotting.

(d) When cars are to be weighed in motion, cut at both ends at a speed not to exceed four (4) miles per hour, scales should be approximately 1-3 longer than the wheel-base of the longest cars ordinarily weighed. Humps for gravity weighing should be so constructed that cars with wheel-bases longer in comparison to scales should pass over scales at a slower rate of speed or be spotted if necessary.

7. Location:

The proper location of scale depends principally on the following conditions:

(a) The volume of traffic to be weighed in comparison with that switched over the scales and not to be weighed.

(b) Whether scale is to be equipped with dead rail or relieving gear.

(c) Whether run-around track will be installed for switching with separate track for weighing.

(d) Whether cars are to be weighed spotted or in motion.

(e) The cost of extra switching, when scales are not located on lead to classification track.

(f) Cost of maintenance when scale is located on lead to classification track and only a small proportion of cars are to be weighed.

(g) The necessity for quick despatch of cars that are weighed.

So much depends on local conditions affecting the different carriers that it would be difficult to give exact rules in connection with the above suggestions, it is recommended, however, that there be not less than 50 feet of tangent track at both ends of scale rail. When only a small proportion of cars handled are to be weighed the rails leaving the scale in the direction of weighing may be curved and the dead rail straight, or the curvature may be equalized between them.

8. Grade:

(a) When scales are located on lead to classification tracks in hump yards, they shall be at sufficient elevation that cars will run by gravity as far as desired into classification yard, considering a maximum speed of 4 miles per hour over the scales.

(b) When scales are not located on hump, they should be at sufficient elevation to provide necessary grade on track leaving scale in direction of weighing that the usual cut of cars to be weighed will run away from scale by gravity in order to prevent impacts on the scale.

(c) The apex of hump shall be located at about the same distance from scale as the length of wheel base of the shortest cars ordinarily weighed. The grade should be such that free running cars as above will pass over scales at a speed not to exceed four (4) miles per hour.

(d) Where it is the practice for one car rider to take several cars together into the classification track, the same grade as on the scale should be maintained for at least 100 and preferably 200 feet beyond the scale in the direction of weighing so that cars may be stopped easily by car rider and that succeeding cars will not cause excessive impact when striking the car ahead which should occur not less than one car length from scale.

9. Foundations:

(a) Scale foundations should be constructed of concrete or cut stone. When the latter material is used it should be laid in cement mortar.

(b) Foundations should be constructed in accordance with the best engineering practice.

(c) Piers or parts of foundations supporting scale stands or dead rail system should be of sufficient area that the pressure per square inch in accordance with the best engineering practice will not be exceeded and must be constructed as nearly as possible to exact elevations. Grouting is undesirable. The tops of piers or supporting walls should be finished with a layer of cement mortar in the proportion of one to one to the depth of approximately one and one-half (1½) inches and after setting dressed to exact elevations.

(e) Where necessary to prevent seepage of water through foundations into the scale pit, they should be water-proofed and drained into a water-proofed cistern located outside of scale pit, and equipped with either hand pump, air siphon, or steam siphon.

(f) Drainage should be provided in all cases where there is a possibility of water getting into the pit and where excessive seepage is not present and there is sufficient fall, pipe drainage should be used.

(g) The minimum period of 10 days should elapse between the placing of last concrete and the putting of the scale in service to permit proper setting of concrete. The proper setting will be influenced by the prevailing temperature and weather conditions during that period, and this should be given due consideration.

10. Installation:

(a) Scales should be installed with dead rail or relieving apparatus.

(b) The deck or platform should be of the rigid type, so that the balance of the beam is not affected by weather conditions, etc. It should be made as nearly dirt and water proof as possible.

(c) Scales to be used for spot weighing should be constructed with scale rails level and approach rails level with scale rails for a distance of 50 feet.

(d) Scales to be used for motion weighing should be constructed with scale rails at not greater than 1% grade.

(e) Wedge or other means of adjustment used between bridge and scale supports to secure uniform distribution of loading should be set as low as possible when scales are installed, as future lining usually requires raising bridge rather than lowering it. End of check rod on scale should be ¼" higher than at point of anchorage.

(f) Some yielding material, such as wooden ties should be placed between bridge and scale rail as a means to absorb shock and protect the vitals in case of derailment. This should not be framed until bridge is installed in order to secure proper elevation of scale rails and should be fastened securely to bridge to prevent shifting.

(g) Scale should be set directly on foundations or on metal bed plates resting on foundations.

(h) Scale parts, where necessary should be securely anchored to foundations, and it is desirable that means of slight adjustment longitudinally and transversely be provided for properly setting scale, interchanging scales in the same pit, etc., in order to secure perfect freedom of action for all parts in suspension.

(i) Scale beam supports should rest directly on scale foundation.

(j) The use of extension levers between fifth lever and scale beam is undesirable.

(k) Scales and structural steel should be cleaned and painted with one coat of red lead paint before being installed, one coat after installation and at such other times as may be necessary.

(l) Minimum clearance for the working of scale parts through or about parts of installation not connected with scales, should not be less than three-quarters (¾) of an inch, except that when scale end approach rails are securely anchored a clearance of not less than half (½) inch will be permitted.

(m) Open hearth scale rails of full length and sufficient capacity for supporting load are desirable.

(n) An efficient transfer rail, or other connection, may be used to prevent impact of cars moving over joint between approach and scale rails, such contrivance to be so designed as not to interfere with the action of scale.

(o) Approach and scale rails should be anchored to prevent creeping and should be maintained in proper line and surface.

(p) Scale pits should be heated wherever practicable and necessary to prevent freezing and rust.

(q) Effective means should be provided for ventilating scale pit where

practicable. Openings in side walls are desirable. Means should be provided for closing such opening when there is possibility of wind pressure affecting the scale when weighing.

(r) Scale pits should be properly lighted for purposes of cleaning, inspection and testing.

(s) Scale houses should be constructed at all track scales for proper housing and protection of scale beam and protection of weighmaster.

(t) The interior and exterior of scale houses should be amply and properly lighted to afford proper facilities for weighing and the prevention of mistakes in reading scale beam, car numbers and stenciled light weights. This applies more especially where cars are weighed at night.

MAINTENANCE, OPERATION AND TESTING OF TRACK SCALES.

11. Maintenance and Operation:

(a) All track scales should be numbered and referred to by number and location.

(b) Extensive repairs to scales, such as renewal of or sharpening of pivots, should be made in properly appointed shop.

(c) When scales are in service regularly, scale parts, substructure and foundations, should be cleaned at least twice a month, and, when exposed to the elements, or otherwise located so that they are liable to become clogged with ice or dirt, should be cleaned as frequently as necessary.

(d) The application of rust preventives to bearings is desirable but they should be so applied as not to interfere with the proper working of scale.

(e) If ice obstructs the levers, salt should not be used to melt it; artificial heat should be used wherever practicable.

(f) Equipment should not be allowed to stand on the scales except when being weighed.

(g) Engines or other equipment not to be weighed, should be passed over the dead rail.

(h) Cars should not be bumped off scales by engine or another car on the dead rail, nor be pulled across the scale coupled to another car moving over the dead rail.

(i) Enginemen should not apply sand to scale or dead rail, nor should the injector on engine be applied when engine is standing on or passing over scale.

(j) The weighing beam should be balanced before the scale is used and when not in use should be locked with beam catch.

(k) Cars should not be violently stopped on scale by impact, by the sudden application of brakes or by throwing obstructions under the wheels. When pushing off scale cars which have been stopped for weighing or otherwise, impact must not occur at a speed greater than two miles per hour. When necessary for any reason to run cars over scale rails, the speed must not exceed four (4) miles per hour.

(l) The weighmaster should familiarize himself with construction of scale and make such inspections at such intervals as are necessary to determine if scale is in proper working condition.

(m) Parties appointed to inspect and clean scales, should be properly instructed, and it is desirable that they be present with the scale inspector when scales are tested.

12. Testing:

(a) The standards of mass for testing scales should be derived from primary weights, verified by the National Bureau of Standards, Washington, D. C., to within what is known as their "Class B Tolerance." Such weights can be obtained either direct or through scale manufacturers. The 50-pound secondary or working cast iron weights, which are transported from place to place and used directly in testing scales, should be rectangular, and of such design as to facilitate stacking; they should be free from pockets, blow holes,

etc., which are liable to catch and hold foreign matter. No adjusting cavity or cavities in the bottom of the weights should be permitted.

These weights should be tested and adjusted in comparison with master-weight, which has been verified to within "Class C Tolerance" (see Appendix 7). The working weights shall be adjusted to within 25 grains and maintained to within 100 grains of their true values.

(b) Scales in regular service shall be tested at least four times annually with test car or test weights up to at least 10% of their capacity.

(c) Scales should be given a graduated test up to their working capacity when installed and periodically thereafter. The necessity for the frequency of such a test depends on the design, capacity and method of installation, of the scale used, the wear of scale pivots, and the amount of weighing performed.

(d) A test shall be made each week by weighing a heavily loaded freight car with as short a wheel base as is obtainable, on each end and center of scales. When scale is equipped with automatic weighing attachment, the car should in addition to the above, be weighed spotted on trip end of scales and in motion with automatic attachment connected. A report of these tests should be sent to officer in charge of scales and weighing.

(e) In addition to the above a daily test should also be made on each scale equipped with automatic attachment, by weighing a car spotted on trip end of scale with beam, also in motion with automatic attachment connected. A book record of this and other tests is to be kept by weighmaster.

13. Equipment for Testing:

It is desirable for verifying or sealing test weights and test cars to have, in addition to standards of mass prescribed above:

(a) An accurate even arm balance of 100 pounds capacity in each pan, sensitive when loaded to two grains.

(b) A master scale of sufficient length and capacity for sealing test cars, which should be sensitive to within one pound in 50,000. It should be installed under cover and properly maintained and tested to insure accuracy.

Scale Test Cars.

(c) For the proper design of scale test cars consideration should be given to the following:

(d) All metal construction.

(e) Length of wheel base.

(f) Uniform distribution of load on axles.

(g) The elimination as far as practicable of ledges or projections likely to catch and hold dirt.

(h) The elimination of all unnecessary parts.

(i) Strength and durability so that frequent repairs will not be necessary.

(j) Surface area to be reduced as much as possible to limit wind pressure.

(k) The accessibility of all parts for inspection.

(l) The ease with which it may be barred or moved by scale inspector.

(m) Weight of car and weight of super-cargo if used.

Note: There is a wide variation of practice in regard to the design of scale test cars. It is thought, however, that the majority of cars weigh from thirty to sixty thousand pounds and have a wheel base of from six to eight feet. Some have a body made up of solid castings with space provided for small supercargo; others have a body of plate steel with space for supercargo or test weights, weighing about as much as the car. Local requirements principally determine the type of construction to be followed. It is not thought, however, desirable to have test car weigh less than thirty thousand (30,000) pounds, nor greater than sixty thousand (60,000) pounds for gen-

eral testing. Heavier cars on two axles up to eighty thousand (80,000) pounds are desirable for use in making graduated tests up to capacity of scales or the capacity of loads to be weighed.

Photographs of test weight cars will be included in the appendices to these specifications. (Plates 1, 2 and 3.)

14. Automatic Weighing and Recording Devices:

Efficient automatic weighing and recording devices may be used where desired. There has been, in the past, however, and may be at present, an impression by some, that the automatic weigher and recorder will overcome all outside influence and give correct results regardless of scale and track conditions and speed at which cars are handled over the scale. This is an erroneous impression as it is absolutely necessary that the scale and the automatic device as well be in first class condition with properly maintained approach tracks and cars must be run at a slow rate of speed with particular attention to steadiness of motion if best results are to be obtained.

DISCUSSION.

(Subject No. 2, Track Scales.)

The Secretary:—Since none of the members of this committee are present I will read letters from A. M. Van Auken, R. C. Sattley and E. E. R. Tratman, which were sent in for the discussion.

A. M. Van Auken (By letter):—An eleventh hour incident coming after I had secured transportation and leave of absence, prevents my being at Montreal with you. For the shortcomings of the report, no apology will be made. The committee has done its best. The material which was secured would readily have made a report three times the size of the one presented and it has been a constant task to tell what to admit and what to cut out. It was a temptation to go deeper into the question of scale design, and to add sufficient information about weighing to give a clearer understanding of the conditions under which weighing is done. It was decided that the former should be left to the engineering association and the latter to the operating department, as these subjects come up to them in the end.

The work of the committee has been fascinating. One of the amusing features was that the advocates of four sections and those preferring five each advanced the same reason for their choice. In another amusing occurrence I was present at a test of a scale which gave very poor results under the test car, and two days later was taken out and shown the same scale by the maker and assured that in its two years of service it had given perfect satisfaction.

In discussing this report, the committee will be aided, and the report will be made of more value if any point where there may be a lack of clearness of expression, or where a statement may be possible of wrong construction, shall be called to the attention of the meeting. Also, if any errors have slipped in, we wish them corrected.

It is possible for men to disagree on many points. The committee was not polled on the subject of number of sections a track scale should have. It is my opinion that for a small road where there is no skilled scale inspector it is best to keep the scale to four sections if the Fairbanks type be used. It is also my

opinion, based on studies and observation, that, where a road is able to keep a competent scale inspector, it does not make much difference how many sections it has. Of course, a four or six section scale is more symmetrical than one with five sections. Some of the advocates of the 4-section type remind me of a book which I read in my youth. It was an English book, printed with the old style " s," which looked so much like an " f." The book was written for the purpose of proving that a truss bridge was a monstrosity, and among other things contended that the joints of a truss could not be made so perfect as to evenly distribute and carry the load. The four section fellows will probably laugh at some of their arguments before ten years are gone.

It was also hoped that we might be able to submit some suggestions for standard plans for scale houses and scale installations. We have a considerable amount of data, and if it pleases the association to continue the work for another year these subjects might be made of value. There are about six different conditions which affect the installation of a track scale, and about four affecting the scale house. Six types of one and four of the other might be developed in outline, leaving the refinements to the individual location.

It is most desirable that a glossary of terms be framed for scale work. Several parts of the scale are known by different names in different localities. Several different names are used for the same part by different scale makers. The question of a steel for the pivot and bearings is a question for continued study. We barely refer to it this year. A broadening of the method of testing that it may cover all types of scales would be desirable.

If you will bring up all the features possible, it will give me pleasure to prepare for the complete report an answer to all questions asked and to answer any criticism. We want your corrections and your criticisms. It does not matter whose opinions are adopted. It is of great moment that all opinions finally shown shall be as near correct as it is possible to make them.

R. C. Sattley (By letter):—I wish to call attention to a report made on track scales in September, 1874, at an annual meeting of the officers and employes of the Empire line, held at Kane, Pa. There is much food for thought in that report which calls to our minds that even 39 years ago the subject of track scales was one of vital importance. I wish also to call attention to the tests made by the Minnesota Railroad and Warehouse

Commission, which has probably advanced farther than any other state in the regulation of railroad track scales.

If the fact was impressed upon our railroad managers that when a scale is not weighing correctly, over 90 per cent of the error in weight is against the railway company, more interest would be taken in matters pertaining to track scales. I think that it would be a good plan if every large railroad system entering Chicago had a master scale to be used for the purpose of weighing cars that had been weighed on other scales on the same road and a report made to the president of the road of errors that show up from other scales on the same road. This master scale should be tested daily to see that it is absolutely correct. In this manner it would act as a check on all scales on the system. It is quite evident that such a system of checking would tend to a higher degree of efficiency pertaining to scales.

The chairman of this committee has been untiring in his efforts to get before this association a great amount of interesting information during the past two years, and I consider that the information is of vast importance to our members and the railroads. I trust that the report will be accepted in the spirit in which it is presented, viz., information as a basis for future recommendations as to what should be the best practice in design, construction, maintenance and supervision of track scales, that the railways may in turn receive a just compensation for the traffic handled.

E. E. R. Tratman (By letter):—As an important item of freight yard equipment the track scale has been considered at different times by the Yards and Terminals committee of the American Railway Engineering Association, of which committee I am a member, both in regard to its design and its operation, and particularly with reference to its use on the hump or incline track of gravity switching yards. In the committee's report of 1908, the length of scale platform was discussed and it was shown that scales more than 60 ft. long are rarely used, and that some of that length had been shortened, as the very long scales were slow in action. The general length was from 36 ft. to 48 ft.,—24 ft. for roads with short ore cars, and as long as 60 ft. in some cases, —the Philadelphia and Reading having 60 ft. scales on switching humps. A 100-ft. scale was used at one time on the Chicago, Lake Shore and Eastern, but there was much trouble in getting cars to run over it by gravity, and its length was reduced to 42

ft. The report also gave particulars of scales and weighing at a number of freight yards.

In its report of 1909, the committee stated that the presence of a scale on the switching hump did not reduce the capacity or efficiency of the yard work. Eliminating the dead rail and running all cars over the scale, whether they are to be weighed or not, would be of very little advantage, as it would not materially increase the speed of working and would be detrimental to the scale. The report of 1910 described a track scale on the Philadelphia & Reading in which the dead rail was supported upon a continuous concrete wall instead of on open iron standards.

The subject of track scales is included in the committee work for the present year, 1913-14. There is no doubt that under present conditions of railway operation and the necessity for effecting economy and eliminating loss in operation, much more attention will be given to the track scale in the future. As your own committee's report has shown, the track scale is an important factor in securing to the railway company its proper revenue. For this reason it must be regarded as a necessary and important part of the road's equipment, and not as a junk machine that serves mainly to hinder the work of the yard men. It needs to be a well designed and well built machine, carefully maintained in good working order, and so operated as to give closely accurate records.

The Secretary:—I was over to St. Paul last week on business pertaining to track scales and had the privilege of listening to an interesting talk by Mr. A. Bousfield, chief engineer of the Fairbanks Co. Mr. Bousfield is here today and if there are no objections I would like to have him say a few words to us for I know that he can say something on this subject that will be interesting.

Mr. Bousfield:—I think we are all free to admit that this subject is one which has been greatly neglected in the past. However, in recent years it has received a tremendous impetus and I believe that every railroad in the country now realizes the vast importance of accurately weighing its freight, so that from the highest official down through the ranks there has been manifested an earnest desire for better scale equipment. Not only the railroads but the various state commissions have taken up this subject and recently the Government at Washington took steps to investigate the correct weighing of freight.

Two weeks ago I had the pleasure of seeing The Bureau of Standards' new test car in operation. I think it is the first attempt of any company or corporation in the country to scientifically test track scales.

The car itself consists of a steel frame box car with a wooden lining. A traveling crane is installed inside the car with a generator set at one end to operate the crane and also to propel a test car which is carried inside the box car. The first operation in testing the scale is to pick up the small test car with the traveling crane, run it out through the end doors (similar to those on box cars made for automobile use) and place it on the scale platform. This small car has a wheel base of five feet, and is equipped with 100,000 lbs. of weights. The majority of these weights are in 10,000-lb. units and have been very carefully sealed and calibrated. The probable error in a 10,000 lb. weight is about 0.3 lb. These weights are placed by the crane on the small car which is equipped with an electric motor with a flexible connection from the generator in the car. In this way it can be propelled over the entire platform of the scale and a graduated test made on each section. In the tests I saw made the car was first run over the scale platform. I think the car itself weighs 5,060 lbs. It is not sealed and it is not intended as a test of accuracy but it is run over the scale platform to see if there is uniformity in the weights recorded in the different sections. Those of you who are familiar with scale construction are undoubtedly aware that it is a difficult thing in any scale to get what is called straight line calibration, that is, to get the scale to respond equally for equal amounts of load. By means of this government test car, a graduated test from 10,000 lbs. up to 100,000 lbs. per section can be made and some of the results obtained are rather startling, particularly on some of the old scales. They start with 10,000 lbs., increasing to 75,000 lbs. for a 150-ton track scale, and they have used from 60,000 to 65,000 lbs. per section on scales of 100 tons capacity.

The scales which I saw tested were comparatively old and did not show up very well. I believe, however, that there is an earnest desire on the part of the Government to coöperate with the railroads and to point out to them lines which they should follow to better their scale equipment. The New Haven and the Boston & Maine extended every courtesy to the Government officials in charge of this car; they went so far as to send one of

their division superintendents with the car to facilitate its movement through the yards.

I do not believe that it is possible for any committee to formulate a detailed specification embodying capacities, length, style of buildings and various other factors entering into the design and construction of a track scale. The design must of course be governed by local conditions and the judgment of the engineers and scale men in charge of the design must be considered. Different roads, or different divisions on one road, may require different kinds of equipment. In certain localities, a short length of track scale is desirable. I have in mind one particular installation on the Duluth, Missabe & Northern, at Proctor, Minn., where nearly all the ore hauled by that road is weighed over two scales. The method of handling that ore is to run the cars down in trains and weigh them over the scales without uncoupling. They use a short track scale, as all the cars are of uniform length. The average wheel base is about 19 ft., and the capacity of the car is normally 100,000 lbs. The scales are installed on a level grade and the approach walls are about 30 ft. long, so that the alinement of the rails can be absolutely maintained. The cars are run over this scale at the rate of about three miles an hour. An automatic registering device is used and the accuracy of the result is startling. I have seen several tests made on these scales. The mode of testing is as follows: a train of a given number of cars is hauled over the scale by an engine, the weights being recorded by the automatic device. Then the cars are uncoupled at each end; each car is spotted on the platform of the scale and the weight is very accurately taken on the beam, with the automatic device detached. On one test of some ten or twelve cars that I have in mind, the average discrepancy between the recorded weight given by the automatic device and the actual spot weight taken on the beam, was only 28 lbs., and the maximum variation in any one weight, I think, was 80 lbs. It is certainly wonderful what can be done in the motion-weighing of freight cars.

I believe a specification for a track scale should be very broad, and that only certain limiting factors should be recognized, such as the stress and the deflection to be allowed in certain members. The deflection in a track scale is a very important factor. It is not good practice to stress the various members in a track scale up to the limit of elasticity. We should keep the stresses down

low enough so that the amount of deflection in the various component members of the scale will not be great enough to affect the accuracy of that scale when it is weighing its maximum load. I believe that many of the discrepancies in weight today are caused by inaccurate light-weighing of freight cars, not sufficient attention being paid when the cars are light-weighed and stenciled in the first instance, and also when they are re-weighed. That again emphasizes the importance of having a scale sufficiently rigid and so designed, constructed and built that it will respond equally for equal amounts of load. One has to first weigh a freight car unloaded; where a weight of 30,000 to 45,000 lbs. is being handled it should be accurately recorded; then when the car is loaded, one may get weights as high as 160,000 or 175,000 lbs. in the case of heavy ore cars, or cars overloaded with coal. In establishing any specification it should be made broad enough to embrace almost any construction which will give those particular results. The length of the scale, how it shall be built, the amount of concrete under the piers, etc., are purely matters for local consideration, it being pre-supposed that the scale must be placed on a rigid foundation. If those broad features, as the limiting stresses, the deflection and the load per lineal inch of knife edge, which is imposed under the maximum load, are fairly covered, one has then eliminated—to a very great extent—the bad effects which have been experienced in the past. Due to competitive conditions certain factors for loading have been established which will undoubtedly be different for different roads and different divisions. The maximum load and the wheel base of the car likely to be handled are questions which the railroad, or the division interested, must first establish. Having established those points and prepared specifications for limiting stresses, knife edge, etc., I do not think there is very much danger of inferior scales being installed.

Mr. Horning:—May I ask Mr. Bousfield what is the allowable amount, in pounds, per inch of knife edge that he would recommend?

Mr. Bousfield:—There has never been any really authoritative test made, but I have always advocated 5,000 lbs. per lineal inch of knife edge for the greatest concentrated load on a section.

The Secretary:—I would suggest that as many of our members as possible read this scale report,—at least the vital points,—and send such information and suggestions as deemed advis-

able to the association to be included in the discussion when the report is printed.

F. E. Schall, (By letter):—In the first place, I consider it my duty to express my appreciation of the completeness of the report in every way; the committee has produced one of the best reports ever presented to our organization, and the chairman of the committee deserves great credit for the good work he has done on a subject concerning which so little has been written.

I have gone over the report very carefully, and I wish to call attention to certain matters contained therein. The length of a track scale for general traffic should be a 4-section scale, 50 ft., available length. The capacity of the scale girders should be such that the heaviest car and lading may be weighed without causing undue deflection in the girders and the scale mechanism should be designed for the same duty; the maximum weight of car assumed for designing new scales should be 130,000 lbs. capacity, 13,000 lbs. excess lading on car, weight of car 57,000 lbs., total weight of car and contents 200,000 lbs. on 4-axles, axle load 50,000 lbs. While few cars of such capacity are now in service, the time will come when they must be handled in the regular traffic. In designing a scale two cars, coupled, passing over the scale to be considered to ascertain the maximum load on any part. The fact that the few heavy cars are already used is sufficient to warrant the consideration of a reasonable maximum weight of car and contents, which in my judgment should be not less than 200,000 lbs.

The feature of overhang for scales is one which in my judgment should be given careful consideration, extremes avoided, and a reasonable mean length of overhang determined upon, which would be generally applicable.

The details of scale construction have been very fully covered in the report, but I feel that we should not condemn the superimposed direct bearing scale for the carelessness with which it has generally been treated and grab at the suspension bearing scale as a remedy for all the ills of previous inaccuracies and other failures.

It has been reliably demonstrated that with proper adjustment and reasonable care in the use of a scale, accurate weights can be obtained with the standard type of non-suspension bearing track scales.

It is also a fact that until recently there were no suspension

track scales, consequently a very large proportion of the existing track scales of today are of the non-suspension type; it would therefore seem an injustice to detract from the merit of the latter or cast any reflection on its integrity under proper maintenance and treatment, by an advocacy or clamor for the suspension bearing type of scales, which type of scales has not as yet been thoroughly tested out, and any superiority claimed for them as to difference of life of bearings has not been established by the proper length of time of usage. In other words, it does not seem just to adopt at this time a single standard of suspension bearing type of track scales, when, as a matter of fact, accurate weights can be obtained by either type of scales; it would be an economic waste to require railroads and industries to change their scales, or be placed in the position of continuing a discredited type of scale, when the suspension bearing type has not been sufficiently tested out to prove any advantage over the superimposed bearing scales.

As to registering devices, such an apparatus is no doubt a desirable adjunct to a scale, but it should be of such construction and character as to admit of registration of weight only when a weight is on the scale and the scale is in balance, the result to be used as a check only. The weighmaster should be required to keep a book record the same as if no registering device was in use; the records from the registering device should not be available to the weighmaster, such records being used as a check only.

SUBJECT NO. 6.

SEWERS AND DRAINS.

REPORT OF COMMITTEE.

Sewers, as referred to in this subject, are intended to carry the excremated matter from railroad buildings to the main sewer, stream or cess-pool. The necessity for prompt and complete removal of sewage from the building and its disposal in a way the least offensive and injurious to health is a matter well worth consideration.

Drains are used in connection with railroads for carrying off surplus water from buildings and pits, and are simpler in construction than sewers. Ordinarily they do not require tight joints and traps, and they are often built of wood or common drain tile; but the larger sizes are usually built of sewer tile.

In order to enable the committee to submit a report on this subject, letters of inquiry were sent to several officials of the various railroads throughout the country and answers were received to about twenty per cent of the letters, which indicates quite a bit of interest on the part of our members to assist in our work, for which we take this opportunity to thank all contributors.

After careful consideration as to the practice, experience and opinions of our contributors, we offer the following as a progress report, hoping that the few points touched upon in this paper will bring forth sufficient written matter and oral discussion to make the subject worthy of publication in our proceedings.

Material.—For sewers cast iron pipe or vitrified sewer tile is recommended, as the conditions may require. Cast iron soil pipe should be of standard weight free from flaws, cracks, air bubbles or other imperfections, and it should be tested to 50 lbs. water pressure previous to tarring.

Vitrified sewer tile should be of standard thickness, good quality, salt glazed and well burnt throughout its thickness; impervious to moisture, smooth and well glazed on exterior and interior surfaces, free from cracks, flaws, blisters, fire checks and other imperfections.

For drains, cast iron soil pipe or common sewer tile may be used, according to the local conditions.

General Considerations.—Sewers and drains should be carefully studied, surveyed and mapped out, both for greater accuracy of work and for location of the line afterwards. Particular stress is laid upon the importance of the grades, to avoid dips or depressions in the line which might work mischief with the system.

The area of the trunk or main sewer should be equal to the area of all intermediate connections, allowing for difference in velocity of flow. The following table will give the approximate carrying capacity of different sizes of drain pipe, in U. S. gallons per minute, for grades varying from one inch to 36 inches fall in 100 ft.

TABLE.

Fall per 100 ft. Inches		Diameter of pipe in inches.								
		3	4	6	9	10	12	15	18	24
1	Gals.	13	27	75	205	267	422	740	1,168	2,396
2	"	19	38	105	290	378	596	1,021	1,651	3,387
3	"	23	47	129	355	463	730	1,282	2,022	4,152
6	"	32	66	183	503	655	1,033	1,818	2,860	5,871
9	"	40	81	224	617	803	1,273	2,224	3,508	7,202
12	"	46	93	258	711	926	1,468	2,464	4,045	8,303
24	"	64	131	364	1,006	1,310	2,076	3,617	5,704	11,744
36	"	79	163	450	1,240	1,543	2,554	4,467	7,047	14,466

Angles in sewers and drains should never be used where it is practicable to do without them. Under ordinary conditions, where it is absolutely necessary to make an angle in a pipe line, long radius bends should be used, on account of less interruption to tne flow. Where it is necessary to provide cleanout basins in a pipe line they may be made to act as the turn. Where the angle is greater than 45 degrees, brick or concrete turns, with a cleanout basin, should be used.

Where necessary, traps should be placed in the pipe line and a hand hole should be provided in the pipe line near each trap, so that the trap can be cleaned or raked. The trap alone offers some resistance to the flow, and where a hand hole is made in the trap it adds another probability of obstruction.

Drains should be provided with a screen or grating at the inlet to keep sticks and rubbish from entering. Where dirt, sand, boiler washings and other sediments are liable to enter, a large catch basin should be constructed as near as possible to the inlet end. In this materials may settle and may be removed, from time to time. If the water carries a fine silt and the drain is of considerable length, other smaller catch basins should be placed in the line, for the same purpose as the larger one. The large basin should have a depth of at least three feet and the smaller ones two feet, below the line of the drain.

When a pipe line is laid in soft earth or in a marsh, it is often necessary to provide a foundation to keep the pipe from settling. We find various methods used, namely: the use of piling, cinders, a concrete base, timbers cross laid, wooden trestles, wooden cradles, and concrete cradles, all of which can be used advantageously. Matters of this kind are decided largely with respect to the material locally obtainable.

Where a drain or sewer is laid by contract, frequent inspection of the work should be made during construction to see that specifications are being carried out, and, where necessary, a regular inspector should be assigned to the work. It is a very difficult and expensive matter to locate a defect in a pipe line after it has been laid and covered.

Where water pressure is obtainable pipe lines may be given a pressure test after laying and before they are covered up. A pipe line may also be tested with air or smoke.

Laying.—Where sewer pipe is laid under buildings or under granatoid or cement sidewalks or platforms, or under tracks, it should be of cast iron; otherwise it might be of best quality, salt-glazed, vitreous terra cotta. All cast iron pipes should be neatly and snugly fitted together, the joints being well caulked with picked oakum and molten soft pig lead, using 12 oz. of lead for each inch of diameter of pipe in which joints are made. No cement or putty joints should be permitted, and wherever connections are made they must be laid with "Y" branches, long curves and one-eighth bends.

Vitrified sewer tile should be laid with joints closely fitted together in such manner that there will be no shoulder or lack of uniformity of surface on the interior of the drain. Each joint should be wiped clean of mortar on the inside before another joint of pipe is laid. The joints should be well cemented together with a mixture of one part Portland tested cement and two parts of clean sharp sand. The cement should be pressed into the space

between the socket and spigot so as to fill it completely. After cementing the joints together care must be taken not to disturb the pipe.

R. O. ELLIOTT, *Chairman.*
A. F. MILLER,
E. C. MORRISON,
K. PEABODY,
Committee.

APPENDIX.

We submit herewith a copy of the circular letter of inquiry sent out, together with extracts from some of the replies received, omitting such matter from some of the replies received as would repeat data or information contained in others.

CIRCULAR LETTER OF INQUIRY.

1. Do you recommend the use of sewer tile, or cast iron soil pipe?
2. Where possible to obtain the desired fall, what grade do you give the pipe per 100 ft. in length?
3. Do you make any allowance in the size of sewers or drains to take care of intermediate connections?
4. Where you have angles in the sewer or drain, do you recommend or use elbows, long bends, increasing bends, crosses or brick turns? If so, state reasons for use of recommendations.
5. Where it is necessary to have trap in pipe line, do you use or recommend the use of clean-out traps? If so please give reasons.
6. In laying drain where foreign matter is likely to enter and choke the pipe, do you make any provision to guard against such? What are your methods?
7. Where you lay drain or sewer tile in soft earth or marsh, what method do you use to prevent pipe from settling and forming pockets in the line?
8. Where sewer or drain pipe is laid by contract, do you place an inspector on the work during construction, or make inspection after the line is completed?
9. After laying a sewer or drain, do you make a test of any sort to locate defects in the line? If so, give your method of testing.
10. In laying cast iron sewer or drain, do you find it necessary to completely fill the bell joint with packing and lead?
11. What do you use for packing pipe joints before leading?
12. What portion of the bell joint of the pipe do you fill with packing?

EXTRACTS FROM LETTERS RECEIVED.

E. B. Ashby, chief engineer, Lehigh Valley R. R.:
1. Cast iron where subject to heavy pressure; elsewhere sewer tile.
2. Grade not less than six inches in 100 feet.
3. We make allowance for intermediate connections.
4. Long bends to prevent reduction of flow.
5. Yes.
6. Frequently use large wire mesh at entrance.
7. Sometimes lay on planks or make cradles of stone.
8. Try to inspect as work progresses.
9. Not unless flow is restricted.
10. No.
11. Usually use a clay if anything.
12. Generally none.

J. Dupree, superintendent water department, Chicago, Terre Haute & Southeastern Ry.:

1. In soft earth I use cast iron pipe; elsewhere sewer tile.
2. I increase size of main at intermediate connections.
3. Grade 2½ to 3 inches per 100 feet.
4. Where practicable I use brick turns. My reasons are that I can start at any angle from a brick turn, and use this turn as a catch basin. Elbows and long bends will stop up.
5. Where necessary to use trap in pipe line, I always use cleanout trap.
6. Where an unusual amount of foreign matter exists I make use of catch basins; also use a screen and clean out the catch basin when necessary.
9. I hardly believe it necessary to make a test if the line is laid according to specifications.
10. In laying cast iron sewer or drain it is not necessary to completely fill bell joints with lead and packing where there is a good foundation. With sewer tile I fill the joints with cement or mortar.
12. The bell joints of soil pipe are about 3 inches deep, and if the earth or marsh is very soft I use 1½ inches of lead. Where I have clay or solid earth for the line I use only one inch of lead and caulk. Care must be taken in caulking cast iron soil pipe, as it is very easily broken.

C. R. Knowles, general foreman water works, Illinois Central R. R.:

1. Specifications for sewer tile should specify tile to be constructed of standard thickness, good quality of vitrified pipe, salt glazed and well burned throughout its thickness, impervious to moisture, of smooth and well glazed exterior and interior surfaces, free from cracks, flaws, blisters, fire checks, and other imperfections. Pipe to be laid in trenches fifteen feet deep, or deeper should be extra strong.
2. Area of trunk or main sewer should be equal to the area of all intermediate connections, of course allowing for difference in velocity of flow.
3. Pipe should be allowed a minimum fall of two inches per 100 feet.
4. Long bends are more desirable on account of less interruptions to flow, than elbows or right angle short bends, except where a brick turn is made, which may be made to act as a cleanout basin.
7. In laying a drain or sewer in soft earth or marsh, the bottom of the trench should be floored and the trenches should be kept free from water. No sewer should be laid in water.
10. If conditions are severe enough to justify the use of cast iron pipe, the joints should be entirely filled with jute and lead and caulked as in laying water pipe.
11. Jute or oakum for cast iron pipe.
12. Joints should be filled in the same manner as in laying water pipe, when cast iron pipe is used, leaving 1½ inches for the lead.

Cement for Joints.—A good mortar for cementing the joints of sewer pipe should be made of a mixture of one part Portland cement and two parts clean sand. This will also answer for cementing joints in cast iron pipe when not subject to pressure or strain.

Joints.—The cement should be pressed into the space between the socket and spigot so as to fill it completely, and a level joint at the end of socket should be made. After a joint is completed care should be taken not to disturb the pipe.

Moses Burpee, chief engineer, Bangor & Aroostook R. R.:

1. Either sewer tile or cast iron pipe, according to circumstances.
2. I think not less than 1 per cent; more is better.
7. I recommend in soft ground to lay cast iron pipe with the ends resting on posts driven firmly into the subsoil, if not too deep. If the latter, wrought iron pipe laid on a cradle or planks.
8. I think inspection after laying and a severe test, with guarantee of contractor, the best.

I. O. Walker, assistant engineer, Nashville, Chattanooga & St. Louis Ry.:

6. Where sewers drain turntables and engine pits, my personal practice is to put some kind of netting over the inlet so that only the very finest matter can pass into the drain. This is very necessary at such places, because engine wipers invariably drop waste, which, I believe, is the worst thing that can get into a drain.

A. M. Griffin, architect, Nashville, Chattanooga & St. Louis Ry.:

6. I construct catch basins with removable cast iron top at intermediate points, with the bottom about 12 inches below the flow line of the sewer.
7. We use cinders on a concrete base.
8. Where the ditch can be left open we usually make inspection after completion, but otherwise use an inspector.
9. We use a water test of 25 lbs. on cast or wrought pipe work, but on sewer tile we make no test.

R. J. Bruce, superintendent of buildings, Missouri Pacific Ry.:

7. I would prevent pipe from settling and forming pockets in the line by either removing the sand or marshy earth or by putting timber under the line to hold it in surface.
10. Where cast iron pipe is laid I would use lead the same as for water pressure.
11. Would jute to bell then lead.
12. Jute to lead recess.

Where a pipe line comes near the surface of a driveway cast iron pipe should be used to avoid breakage. It is good practice in installing a sewer line 12 inches in diameter and up, to provide manholes at all points where change in direction is more than 45 degrees. The character of sewage that is to be taken care of should regulate the distance between manholes, and where much paper or rubbish finds its way into the sewer the outlet pipe at the manhole should be provided with a suitable strainer.

C. H. Fake, chief engineer, Mississippi River & Bonne Terre Ry.:

7. Have not had any experience in such places, but think I would try laying the pipe on a bed of cinders.
8. An inspector on the job, and he must not be off or get off of it while the men are at work.
9. No, unless city ordinance requires a test and then it is made to conform to ordinance.

W. H. Courtenay, chief engineer, Louisville & Nashville R. R.:

1. We ordinarily use cast iron pipe under buildings, platforms, and other places where the pipe would be difficult of access in case of breakage or other trouble.
7. Wooden trestles, wooden cradles, concrete cradles.
8. Generally an inspector, sometimes an inspector and final inspection.
9. Not ordinarily. In buildings we usually specify that the drain shall be stopped at the lower end and filled with water to the roof line.

C. A. Lichty, Inspector, Chicago & Northwestern Ry.:

1. With perhaps few exceptions, ordinary vitrified bell jointed sewer pipe with cemented joints will answer for railroad sewers, unless the sewage has to be disposed of under pressure to a higher level, in which case cast iron pipe might have to be employed.
2. Sewers should have no less than two and one-half inches fall per 100 ft., and more if it can be obtained.
4. Where a bend or sharp turn occurs in the line, a man hole should be constructed; this will permit of the free use of sewer rods or chains when it becomes necessary.
7. Where pipes are laid in soft ground or marshes it is often necessary to support them on a layer of boards or planks and in special cases it

may become necessary to support this layer of wood on posts or cross-timbers.

8. To insure good results sewer work should receive careful inspection during construction.

9. It is poor policy to try to correct defects after a sewer has been built, and careful inspection of the work should be insisted upon during construction.

DISCUSSION.

(Subject No. 6, Sewers and Drains.)

Mr. A. S. Markley:—In the third paragraph on the second page of the report, it is stated that " where dirt, sand, boiler washings and other sediment are liable to enter, a large catch basin should be constructed as nearly as possible to the inlet end. In this materials may settle and be removed from time to time." We have recently had some experience in that direction with boiler washings; we put our catch basin as near the inlet end as possible. After we had it in, we discovered that the sediment had settled beyond where we installed it. We then put in a second basin some 200 ft. from the inlet and find that this will catch the sediment better than the one closer up. We also found in this same line that the pipe had filled up that far away from the inlet and not nearly so much so at the inlet. The boiler washings will float to a certain extent for a certain distance, when they will settle. In placing the catch basins in this manner I am satisfied that good results will follow, because if the sediment once gets by the inlet the conditions are just as bad unless smaller catch basins are put in.

The Secretary:—We place a large catch basin just outside the engine house, say within a hundred feet. This will catch all heavy material which may be washed into the sewer. Then at intervals farther down the line we place smaller basins, each of which catches more or less sediment. If all of these basins are cleaned out whenever necessary no trouble will result in the pipe line. These basins can be constructed of old timbers, or if greater permanency is required they should be built of brick or concrete.

Mr. O'Neill:—I would like to ask if some of the members who have had experience in laying pipe have found that 12 oz. of lead per inch in diameter of the pipe was sufficient to make good joints for cast iron water pipe?

The Secretary:—Plenty for sewerage purposes and that is all we are considering under this subject.

Mr. A. S. Markley:—Why would you use lead and oakum in cast iron pipe and cement in the sewer tile? We cement both kinds and we have had good results so far. I cannot see why one should caulk iron pipe laid in the same line with sewer pipe which has the joints cemented.

Mr. Dupree:—That may refer to cast iron pipe laid in a marshy place. Lead is better than cement in such places as it is pliable to some extent. The joint is not so easily broken as a cement joint.

Mr. A. S. Markley:—We do not lay cast iron pipe in a marshy place as we can't hold it there.

The Secretary:—We use a great deal of it in marshy places and I presume that others do also.

Mr. Knowles:—Regarding the question of laying the cast iron pipe as sewer pipe; where used as such the conditions are generally accepted as being more severe than for vitrified pipe and for that reason it has been assumed that it should be laid as nearly as possible under ordinary conditions, and for that reason they use oakum and lead. However, I have known of instances where cast iron pipe has been laid for low water pressure, where cement joints have been used, also soft pine wedges. I do not endorse that method, but the pipe will sustain pressure, and if conditions are such that the pipe will not pull apart or settle, one can use cement joints, as Mr. Markley suggests. However, if conditions are severe enough, I think it would be advisable to use lead and yarn. Of course, if the pipe is to be laid in a soft, marshy place, one ought to first floor the ditch and protect it in such a way as to keep the pipe from settling.

Mr. J. S. Robinson:—In laying sewer pipe for engine houses, etc., we always build a large sludge basin just outside the engine house. Engine houses are usually built in cities. Where water is to run into municipal sewers (and there is generally an ordinance against allowing the water to run into those sewers), we catch it in a sludge basin, divided into compartments, so that when one fills it can be readily cleaned out while the other is in use. These basins are quite large and cost about $500 if built of concrete or brick. We use a gate to shut off the sewer, putting in a Y so we can shut the gate in either leg and let the water flow

into the other side. In that way we keep the sludge entirely out of the sewer.

Mr. Ewart:—On the Boston & Maine we laid quite a lot of 12-in. cast iron pipe with lock joints at one time. This comes in lengths of about 4 ft. and when they are fitted together they are given a twist that draws them up tight and the joints can then be cemented on the outside if they are not absolutely tight. That makes a very good joint, because it is a little elastic. If I were going to lay a cast iron drain pipe with lead joints, I think I should want to use more than 8 oz. of lead per inch diameter; that would hardly be enough. There is a rule in the city of Boston which we use on our road; the number of pounds of lead used for a joint is double the diameter of the pipe, so that in laying a 12-in. pipe we use 24 lbs. of lead per joint. This is for pressure mains.

Mr. MacKenzie:—The last paragraph in the report says, "In laying common sewer tile for drains, we recommend cementing the joints the same as in laying sewer pipe." Does that refer to small tile, such as 3 in. or 4 in.? If so, it is something I never saw done. A great many tile are laid for drainage purposes in the marshy lands of New Brunswick and I have yet to hear of the joints being cemented.

The Secretary:—I think that last paragraph is misleading, for many drains do not require cemented joints.

Mr. A. S. Markley:—In laying sewer tile in Illinois, if we want to take care of surface water only, we usually lay it without cement, to allow the water to find its way into the tile along the line for a distance of 10, 15 or 20 ft. on each side of the tile, depending on the character of the soil; but if we want to use it for sewer purposes, the joints are all cemented, in order to make them lie straight, as well as to keep out willow roots which sometimes grow in the tile and plug them up entirely.

Mr. J. S. Robinson:—For sewers we usually use the bell end sewer pipe. For drainage purposes, we use a straight pipe without any socket and leave the joints open, whether vitrified or common tile. Of course, if it is sandy soil, it will fill the tile and one has to use something to prevent that. For ordinary drains for drainage purposes, we leave the joints open and never lay the bell end sewer pipe.

Mr. Sheldon:—In laying pipe in ordinary soil we have no trouble with loose joints, but we laid 800 ft. of pipe through

quicksand and found it very necessary to cement the joints. We started without doing so and found that we soon had our pipes full of quicksand and had to cement each joint as we went along.

Mr. A. S. Markley:—In cases of that kind, we use nearly altogether socket tile sewer pipe, usually seconds, which are much cheaper than firsts and nearly as cheap as the common tile. Wherever we come in contact with sand, we put straw around the pipe and then fill it in to preserve the drainage quality of the tile. That allows the water to enter the tile and excludes the sand.

Mr. Ewart:—In the east we use burlap.

Mr. E. U. Smith:—It has been my experience in laying terra cotta pipe for sewers that the joints should be cemented inside as well as outside. In laying large pipe we found the best plan was to get a man inside with a bucket to cement all the cracks he found inside, otherwise there was considerable leakage from outside sources. In the sewer we have a certain amount of drainage and want to do away with all the outside sources, as we have enough to take care of inside. In small pipes we had the foreman make a circular tool with a rod on it to wipe the joints and help fill up the cracks.

The Secretary:—As I understand it, if we adopt this report, we simply recommend that we would cement the joints of all these pipes, even for drains. I do not think it is right that we should do that. It is all right to do that in cases like Mr. Sheldon has cited, but I do not think we should make it universal. Therefore, I would recommend striking out the last paragraph.

(A motion in accordance with this suggestion was seconded and adopted.)

Subject No. 7.

MOTOR CARS FOR BRIDGE GANGS.

REPORT OF COMMITTEE.

After having prepared a circular letter to be sent to the various railroads requesting information concerning their experience with motor cars for bridge gangs, it was found that the *Railway Age Gazette* was engaged in tabulating the same information which was later published in their issue of July 18, 1913. The committee was given access to this information before publication and accordingly did not send out its letter but took the following information from the replies to their letter:

Number of Cars in Service.

Inquiries were sent to 108 railroads and replies were received from 95. In brief, it was found that 48 roads of this number had in use a total of 3,306 motor cars in all branches of maintenance work. These 48 roads were using 2,246 motor cars in section service for a period ranging from six months to four years, and 24 roads reported using 270 motor cars for bridge gangs for service varying from six months to three years. The rest were used by signal maintainers and for inspection service. Although 3,306 cars were thus reported in use on these 95 roads, excluding over 200 cars incompletely reported on and many others known to be in service but concerning which data were not available, the use of these cars is still in its infancy. Many roads have not investigated the subject to any extent, while on the other hand, other roads now have large numbers of these cars in use. Thus, the Chicago, Milwaukee & St. Paul has 554 cars in all classes of service; the Missouri Pacific 363, of which only 52 have been in use over two years; the Chicago & North Western 549 cars, all secured within the last two years, and the Great Northern 312 cars.

The use of these cars for bridge gangs is even more in the early stages of its development, as is shown by the fact that of the 3,306 cars reported, only 270 are used by bridge gangs on 24 roads. This is in spite of the fact that in many ways these cars are of greater advantage to bridge gangs than to section gangs. Because of the limited use of motor cars for bridge gangs up to the present time, only general conclusions can be drawn and this report must therefore necessarily be one of progress only. Many improvements in the cars are being made by the manufacturers which tend to greatly increase their reliability and general serviceability. Likewise, more extended experience is showing to the roads improved methods of operating the cars as well as keeping them in repair.

Cost of Operation.

Any data relative to the cost of operation of motor cars must be considered in view of the fact that these cars are still being rapidly improved. Even more important in discussing the relative cost of operation of different cars is an analysis of the service conditions under which these cars operate. For instance; the performance of a small car carrying a painting gang of three or four men cannot be fairly compared with a large car carrying a bridge gang of 10 to 12 men. To enable such comparisons to be made upon a fair basis one road at least is now figuring the performance of these cars upon a ton mileage basis.

Considering the above, the following shows a summary of the cost of operation of the 270 cars used in the bridge gangs as reported by the 24 roads and also of other cars for comparative purposes.

Fuel.

	Per 100 mi.			Per Month.		
	Min.	Av.	Max.	Min.	Av.	Max.
Section	$0.40	1.10	4.00	$1.00	3.20	5.00
Bridge	0.25	1.20	4.00	1.50	3.00	5.00
Maintainers	0.17	0.45	.90	1.50	3.15	5.00
Inspection	0.24	1.07	4.00	1.15	2.37	4.25
Miscellaneous	0.11	1.16	4.00	0.30	2.18	4.00

Repairs.

	Per 100 mi.			Per Month.		
	Min.	Av.	Max.	Min.	Av.	Max.
Section	$0.88	1.04	1.25	$0.36	2.10	10.00
Bridge	1.00	1.60	2.21	0.35	1.73	3.81
Maintainers	...	...	...	0.75	2.20	4.58
Inspection	0.35	0.91	1.95	0.45	1.30	2.81
Miscellaneous	...	...	...	0.50	1.50	2.80

It is seen from the above that the average total cost of operating cars for bridge gangs is $2.80 per 100 miles as compared with $2.14 for section motor cars, which is what one would expect in view of the relatively larger bridge gangs. The accompanying tables give in more detail the cost of operation of several cars on individual roads. The first one gives the results of a test of four motor cars, three being in use by track gangs and one by a "floating" bridge gang.

Type of Car.

In adopting motor cars an important question to be considered is the type of car best suited to the conditions which will be met on that road. For small gangs a number of companies are manufacturing a small engine to be placed on the old hand cars. This type has been installed for the use of section gangs on a number of roads with general satisfaction and is of special advantage where gangs are reduced to two or three men in the winter as it is lighter to handle and more easily removed from the track. However, this advantage is of more importance with section gangs than with bridge gangs, which are usually larger in size. For this reason the more rigidly constructed motor cars built for the purpose are better adapted for the larger bridge gangs.

There has been considerable discussion regarding the relative merits of 2-cycle and 4-cycle engines and each has its advantages. The manufacturers of 2-cycle engines point out the fact that it is possible to mix the lubricating oil directly with the gasoline, eliminating the possibility of trouble resulting from neglect to fill the oil cups. The principal advantage, however, of the 2-cycle engine is its greater simplicity in operation. The makers of the 4-cycle engine call attention to the advantage of this type in that it is more efficient in the use of oil.

One must also consider whether a water cooled or air cooled engine is best adapted to his service, depending largely on whether the car will be used for long continued running or intermittent travel for short distances. He must also decide whether a direct connected or friction drive is preferable and must determine the amount of power required for his car.

Advantages of Motor Cars.

The principal advantages from the use of motor cars for bridge gangs are the lengthening of the territory which a gang can cover properly, economy in labor, increased efficiency of the men due to their not becoming

fatigued by pumping the hand car to and from work, the saving in time in transferring a gang from one job to another, the elimination of work train or way freight expense and the moving of small amounts of material; also, gangs can be quickly collected to repair washouts or bridges burned out.

The companies using motor cars are practically unanimous in reporting favorably on their use. For instance the Sunset Central lines of the Southern Pacific report that the efficiency of bridge gangs was increased 40 to 50 per cent by the adoption of motor cars. The Kanawha & Michigan reports that bridge gangs are able to do one-third more work. Likewise, the Central of New England reports a saving of from one to three hours per man per day as the result of motor cars. Contrary to the general impression prevailing a number of roads call attention to the fact that their motor cars are very reliable and that the percentage of time lost by cars out of service is almost negligible.

In the Engineering News of May 22, 1913, appeared an article by J. A. Stocker, chief engineer of the Toledo & Ohio Central regarding the use of 21 gasoline cars on 20 sections during the last six months of 1912 with the following results:

Average cost operation and repairs 0.98 cents per mile with a minimum of 0.67 cents and a maximum of 1.77 cents, the latter on a car operated over some 2.5 per cent grades.

Average mileage per car, 1653 miles; being 23 miles per gallon of gasoline; 345 miles per gallon of lubricating oil; 655 miles per pound of grease; and 181 miles per battery cell.

All of these cars except two were new and consequently repairs were not heavy. Mr. Stocker does not consider the use of motor cars especially dangerous.

In connection with the results obtained by the use of motor cars for the use of bridge gangs, the engineer of bridges on a prominent railroad reports as follows in regard to the use of two cars:

"A two cylinder car is used on steel bridge painting. The men are housed in camp cars at some siding near a telegraph office and the motor car is used to haul them and their materials to the bridge sites and back. When the bridges are small it is necessary to have work on several of them under way at one time, on account of the necessity of allowing some to dry while others are being painted. In such cases the car is almost indispensable.

"The men usually return to the outfit for dinner. The gang averages 12 to 18 men and the distance traveled runs from about 40 miles per day to a maximum of 150 miles. The gasoline consumed is about one gallon for each 15 miles traveled. The time saved is about one-half hour per day per man, equivalent to a total of about $2.50 per day, except that where jobs are small and much territory is to be covered, the saving runs to $10 or $15 per day.

"This car has been in use three years. The wheels have been renewed once. Other repairs have cost but a small amount.

"We have a 3-cylinder car in use on steel bridge erection and repair work to haul men and small tools from their camp cars on the nearest siding to work and back, usually with a trailer attached. The gang averages from 15 to 30 men; the distance traveled is about 30 to 40 miles per day; the amount of gasoline used is about one gallon per 10 miles traveled. The foreman estimates that he saves 40 to 80 hours' labor per week, or the car is worth about $3.50 per day. It has been in use for one year and has required no repairs.

"The motor cars have been very successful with us. The great drawback to them is the danger of collision with trains. We have found it necessary to make some very strict rules. We have had no accidents, but we have had some close calls."

With the adoption of motor cars it is necessary to put into force strict rules for their operation and to use increased care in traveling over the road, especially at points where the view is obstructed. The men should always be required to secure information regarding all trains at every telegraph or tele-

GASOLINE MOTOR CARS.

Kind of service,	Track gang	Track gang	Track gang	Floating brdg. Gang
Cost of car,	$104	$235	$300	$933
Weight of car,		890	900	?
Placed in service,	July, 1912	Aug. 1912	Aug. 1912	July, 1912
Days in service,	144	124	119	124
Days out of service,	0	0	0	0
Miles operated,	1877	1681	1190	3607
Average men daily,	5	4	4	15
Gallons gasoline,	48	64	49	366
Cost gasoline,	$6.92	9.28	7.10	53.07
Miles per gal. gasoline,	39.1	26.3	24.3	9.6
Gals. lubricating oil,	3⅛	3¾	4½	26
Cost of " "	$.75	.90	1.02	6.24
No. spark plugs,	1	3	2	2
Cost " "	$1.25	3.75	2.50	2.50
No. battery cells,	6	0	6	8
Cost " "	$.81	0	.84	1.11
Miscel. repairs,	0	0	0	0
Total cost to operate,	$9.73	13.93	11.46	62.92
Saved in time, (hours)	721	655	423	716
Value of time saved,	$90.12	81.87	44.41	286.08
Cost per mile,	.0052	.0083	.0096	.018

Note:—Time saved refers to saving over use of ordinary hand car.

Month	No. of Cars	Mileage	Time travlg.	Speed	No. of men	Galls. gasoline	Gal. lub. Oil	Av. cost per mile. *
July	19	5125	447 hr.	11 +	7	275	16	.0067
August	19	5864	516 "	11	7	301	20	.0059
September	19	4917	450 "	11	8	254	14	.0128
October	19	5855	530 "	11	7	316	17	.0134
November	19	4322	392 "	11	6	213	12	.0072
December	19	4286	378 "	11	6	220	12	.0124

* Including repairs.

Year purchased	Gals. gasoline.	Cost opr'n.	Cost repairs	Total Cost	Total Miles	Gal. Gaso. Per Mi.	Cost per mi. opr. & reprs.	Av. cost per yr. opr. & repr's.
1906	925	$159	$305	$464	13935	15.0	$.0335	$66.31
1910	494	90	119	209	9312	18.9	.0225	69.73
1909	765	128	160	288	14806	19.4	.0194	71.99
1910	72	16	39	55	2130	29.7	.0258	
1910	202	37	97	124	3309	16.4	.0374	41.32
1912	132	30	5	35	2233	16.9	.0154	34.60
1912	153	33	5	38	3120	20.4	.0119	37.44
1912	98	22	5	27	1643	16.7	.0161	26.55

THIS TABLE FOR ONE MONTH,—JAN. 1913.

Section number	Gallons gasoline	Miles per gal. gaso.	Pts. lub. oil.	Mi. per pt. lub. oil.	Total Cost	Miles operated	Av. cost per mi.
14	10	28	2	140	$3.48	280	012
37	17	32	11	49	2.66	540	005
43	16	29	7	67	2.36	468	.005
44	11	17	4	46	1.59	185	.008
45	18	15	2	134	2.42	268	.009
46	25	18	8	56	3.57	447	.008
48	20	27	10	55	3.00	550	.005
49	17	19	8	42	2.53	335	.007
50	20	12	8	31	2.92	249	.011
51	19	20	9	42	2.83	380	008
52	16	16	6	41	2.32	251	.009
53	16	17	8	35	2.40	278	.008
54	25	21	8	66	3.57	526	.007
55	30	20	16	37	4.54	589	.008
56	6	30	3	60	2.10	180	012

phone station; to flag in especially bad places where the view is obstructed; to limit the speed at which the cars are to be operated; to allow none but employes in discharge of their duty to ride on them; to be very careful in passing highway and street crossings not to frighten teams; to carry proper lights after dark, etc.

CONCLUSIONS.

As the result of our study your committee submits the following conclusion:

The method of using hand power to propel bridge men, with their tools and material over the road is obsolete. Gasoline motor cars have ceased to be an experiment and in the hands of careful men can be safely and economically operated. They will result in savings to the company and comfort to the men.

Your committee also wishes to make the following recommendations regarding the specifications of the cars used:

The car should be as light as is consistent with the requisite strength and should not weigh more than 1,000 lbs. It should be designed so that the greater part of the weight is on the axle with the loose wheel to enable men to take it off of the track easily. If water cooled, the use of small pipes that freeze easily in cold weather should be avoided and the water cooling apparatus should not be added at the expense of very much additional weight.

The car should be designed so as to run at the same speed in either direction with equal safety. The motor should be started with the car at rest and the car started by use of a clutch or belt.

The maximum speed should not be more than 20 miles an hour. It is very desirable to have at least two speeds in either direction to enable it to pull heavy loads over steep grades at low speed and to increase the speed where the grades are lighter.

The car should be designed as simply as possible and with a view of having all parts easily accessible.

R. C. YOUNG, *Chairman.*

DISCUSSION.

(Subject No. 7, Motor Cars for Bridge Gangs.)

Mr. A. S. Markley:—I am in favor of motor cars first, last and all the time, but there are a couple of paragraphs that are considerably overdrawn. I do not believe I would want to vote for the acceptance of that report on that basis, where it says that the men are saving 40 per cent or 50 per cent of their time by using motor cars.

The Secretary:—That is a statement made by some men; whether they can prove it or not is not for us to say.

Mr. A. S. Markley:—Another statement was that they ran 150 miles on motor cars to paint. Hadn't they any side tracks on that 150 miles where they could put their outfit?

Mr. Reid:—One hundred and fifty miles covers the entire length of four trips on the road, going out in the morning, back to lunch, out again and back in the evening; that would imply 37½ miles run each time, but it would seem as if there should be

locations nearer to the work than 37½ miles on any railroad. There are cases, however, where one cannot place camp cars on a side track and it is sometimes necessary for cars to be from 10 to 12 miles from a job, even though there may be sidings nearer. However it does not seem necessary to keep cars from 35 to 40 miles from a job. In as far as accepting the report of this committee is concerned, I do not think that accepting the report of a committee binds the Association to a recommendation of the facts stated in that report. That is simply the work of the committee, and if the Association cares to make any recommendation, it is independent of the committee report. If the committee has faithfully done its work and the report gives evidence of care and attention to details, I think we can safely adopt it if we so desire, without committing the Association to any recommended practice.

Mr. O'Neill:—I don't believe that anybody who looks over the acts of this association will hold us responsible in any way for a statement made to a committee by somebody that knew, perhaps, what they were talking about. I am not prepared to say that the man that made that statement that cars run 150 miles a day at times, was wrong. The cars may have doubled back and forth over the track several times, taking men from one job to another. I don't see that that has anything at all to do with the report of the committee. It is simply a statement made to the committee by somebody from whom they were seeking information.

Mr. A. S. Markley:—If we vote on that, "aye," it signifies that we coincide with it and we will be told—"Your association adopted that report and you endorsed it."

Mr. Knowles:—With reference to 150 miles a day, it is possible that the car made 8 or 10 trips a day, hauling material. They are often used in hauling bridge timbers, etc., out to work, the material being carried on a trailer, and the car would make its mileage in that way. Of course, they are often used on bridge inspection but I don't suppose that such a car would be properly a car for bridge gangs. An inspection car might make 200 miles and over on these trips.

Mr. Reid:—While motor cars have failed and sometimes fail now, there is no doubt that they are better than they were. The manufacturers are improving them, so that they are more reliable and give better service. During the last two or three years

I have been out all day long on motor cars and haven't had any trouble with them, running 40 miles at a stretch without a stop and without the car skipping. That is pretty good work with a little gasoline engine, but as I said before, we have also had trouble running a few miles. We have a section car that has given excellent service. We have several inspection cars and most of them give good service when properly taken care of. We have one car that is used by various forces. It belongs to the bridge department, but we have loaned it to the signal department, the engineer, road master and others who have had occasion to use a light motor car in getting over the road. This car has caused more or less trouble, simply because it is used by so many different people and no two of them have the same ideas of taking care of it. I think a limit of speed of 20 miles per hour is perhaps a little low on a good car. I think a section car can be safely run up to 30 miles per hour, although it may not be advisable to run it at all times at that speed. There may be urgent conditions that make it desirable to get to a place as quickly as possible.

Mr. Rear:—Talking about having trouble with gasoline motor cars, I wonder if anyone here has had any trouble with pumping a hand car? I have always found that men on a hand car will pump much harder down hill than up hill. I think that every one of us has had what one might term his fill of the old hand car. The motor is what we ought to use and it is nearly foolproof. I have known men to run an automobile six months who couldn't wind an eight day clock. Thirty miles an hour is all right if we know who will run the car. On our road we limit the speed to 15 miles an hour. When you get up a rule limiting speed, you are limiting certain men; the section foreman is the man we are after. If the division engineer or the general manager was on the car he wouldn't hold himself down to 15 miles an hour, but on the ordinary track, where there are more or less curves and frequent train service, 15 miles an hour is fast enough. In regard to adopting this report, if a man says he runs 150 miles a day or 300 miles a day, we won't have to say they can go that far. We probably have control of our bridge gangs so we can cut down the joy riding.

Mr. Dupree:—Either a homemade or the manufactured motor car is a good tool. I might claim to be almost the pioneer with a homemade motor car. Some four or five years ago I bought a small engine and applied it to a hand car. It is still in

use. I have a smaller car which I now use, and a report of the mileage made is as follows: The car was placed in service April 3, 1913. During April, I ran 390 miles; in May, 690; in June, 712 miles; July 1st to July 14th, 330 miles; July 14th to August 26th, inclusive, 1,645 miles; from August 26th to October 13th, 864 miles. Altogether, the mileage made last year amounts to a total of 11, 930 miles. On this mileage, this car has gone an average of 50 miles per gallon of gasoline. The total repairs required consist of one sprocket chain to replace a worn-out one, and a set of large wheels. The reason I have so much mileage on our small road is that we have no passenger trains, as our line is practically a coal road. The only way I have of getting over that line to reach water stations and other work is with this motor car. This car has given excellent service, and, as Mr. Rear said, it is almost foolproof.

Mr. J. S. Robinson:—Well, they are not foolproof, and I know it. I ran over a little stone once and was laid up four months. We had a foreman that thought a stone was a little sparrow on the rail, but it was another stone, and he was laid up for two months. I think the cars for bridge and section gangs should be limited by the manufacturer to 15 miles an hour. The Northwestern had a bad accident recently caused by men trying to go as fast as they could, to beat a train. A timber fell from the trailer, the men all went in the ditch and quite a number were injured. I think that heavy cars either for section men or bridge men, should have the speed limited to 15 miles an hour. If the car is made to run over 15 miles an hour, the men will exceed it.

SUBJECT No 8.

TEMPORARY STRUCTURES FOR SUPPORTING TRACKS DURING THE CONSTRUCTION OF PERMANENT WORK, SEWERS, ETC.

REPORT OF COMMITTEE.

Your committee prepared a set of 15 questions which were sent out in the form of a printed circular letter to 240 members of the association and to other railroad officials. At the time of writing this report 58 replies had been received from 52 different railroads. After studying these replies it was decided that the information contained therein could best be presented in a summary which was accordingly prepared and is made a part of this report. It was also thought advisable to print a portion of these replies, giving the most direct information, as part of this report. Although plans accompanied many of the replies, in practically all cases the practice is to follow as closely as possible standard trestle construction and it was not therefore deemed wise to burden the report with these standard plans.

LIST OF QUESTIONS AND SUMMARY OF REPLIES.

1. In locations where there has been no opening in the roadbed, do you put in temporary stringers and ties first, or drive piles first? Give reasons for your practice.

In looking over the replies it will be noticed that there is practically a unanimity of opinion as to the best method of making an opening under the track, as out of the 58 replies received, 45 recommend driving the piles first, while 4 prefer to put in the stringers first and drive the piles afterwards.

2. In locations similar to the above is your first choice piles, framed bents or crib work where conditions will permit the use of either? Give reason for your practice.

Forty-seven reported favoring piles as first choice, two favored framed bents and four favored crib work.

3. To what depth do you excavate on each drift when using framed supports in locations similar to the above mentioned?

Eighteen reported that this method was not used, nine did not answer the question, six replied that the depth depended on the character of the ground, seven reported depths ranging from 12 in. to 15 ft., and the remaining replies were so worded that it was evident that the writers are not ardent supporters of this method of work.

4. What is the standard length of span for falsework?

The standard length of span for falsework as reported ranges from 10 ft. to 32 ft. and in most cases is the same as the standard trestle span, being changed to fit local conditions on a particular piece of work.

5. What is your practice on falsework spans longer than the standard?

In increasing the length of span the common practice is to first add more stringers and some use second hand I-beams, old girders or even trusses.

6. What width and depth of opening limit the use of stringers only, resting on earth at each end?

The answers received show that each of the writers has his own way of handling a case of this kind and that the methods as reported are nearly all different in actual figures given.

7. At what depth of fill would you tunnel instead of trestle?

8. What do you recommend for supporting tracks when tunneling process is used?

Questions 7 and 8 were also answered in such a manner as to indicate that there was a considerable difference of opinion regarding the best way to do work of this kind, the depth of fill given varying from 10 to 50 ft. There is also a difference of opinion as to the amount of support needed for the track.

9. Do you prefer framed, or pile bents, or grillage in supporting tracks when rebuilding bridges, where the bottom permits of framed bents?

Twenty-six replies favored pile bents, 21 favored framed bents, one favored grillage and the remainder would use either pile or framed depending on the character of the ground.

10. Do you recommend a detour temporary trestle for traffic, or a trestle under the existing bridge to permit dismantling the structure and carrying traffic in the reconstruction of bridges? At what limit of height of trestle do you consider that to be the governing feature?

Twenty-two reported not being in favor of using a detour trestle, eight reported in favor of it and six reported no experience or did not answer. The remaining replies are either given in the abstracts from the letters or can be classified among those reporting that they would use either method, the choice depending on the volume of traffic, how complicated the erection of the new bridge was and the comparative cost. The second half of the question was answered by 12 who gave figures varying from 10 ft. to 100 ft. as their idea of the height of the limiting trestle. Several others stated that they did not consider the height of trestle the governing feature.

11. Do you recommend building a new bridge complete on horses on one side, and rolling it in, or supporting the old structure on falsework and rebuilding in place?

The answers received to this question are hard to classify in two classes. The general opinion seems to be that with trusses it is better to build in place and with girders to either lower them in place with derricks, steam cranes or gallows frame, or to erect them at one side and roll in.

12. When renewing steel structures is it advisable to take out the old metal floor system, replacing it with timber, or leave it until the new superstructure is ready to be put in when placing the temporary trestle for traffic and dismantling under the old structure? Give details of method used.

Twenty-four replied that they favored leaving in the old floor system, five favored removing it, eleven reported no experience or did not answer, two that the method depended on the structure and the remaining replies went into such detail that they are not given in the summary but will be found in the abstracts from letters.

13. In rocky bottom do you use long sills for the whole horse, or short sills for separate posts, or omit the sills altogether on temporary falsework where the bottom is uneven?

Eight replies favored the use of long sills leveled up or anchor-bolted to the rock, nine favored short sills, 22 would omit sills altogether, five did not answer, three stated that the method would depend on the character of the bottom and the velocity of the stream and several answered whose replies are given in the abstracts from letters.

14. Bracing. Details of, for (a) simple trestle; (b) double deck, that is, with pony bents.

15. Pony bents—how attached to main bents (scab plates, metal or wood, bolted or nailed). Do you use runner timbers or girts on top of main bents?

Twenty-nine answers to question 14 were received and as already stated the practice seems to follow very closely the standard trestle plan of each individual road. This is also true of the 35 replies received in answer to question 15.

EXTRACTS FROM LETTERS.

F. L. Stuart, chief engineer, Baltimore & Ohio:—The relative advantage of erecting a temporary detour trestle depends largely upon the tvpe of permanent structure to be erected. If the new structure has a solid concrete floor, it sometimes pays to detour traffic. This, however, can usually be just as economically handled by building the new structure to one side, and then

rolling the new bridge into place and the old bridge out between trains, avoiding the necessity of carrying traffic on falsework.

As a general proposition, it is not economical to replace the old metal floor with a timber floor, but, where a bridge is to be erected under traffic, falsework should be designed to carry both the old and the new structure. After the old trusses have been removed, the old floor can be taken out and the new floor placed a panel at a time, in which case it is generally necessary to use some timber stringers to fill out the space between the old and the new panel points.

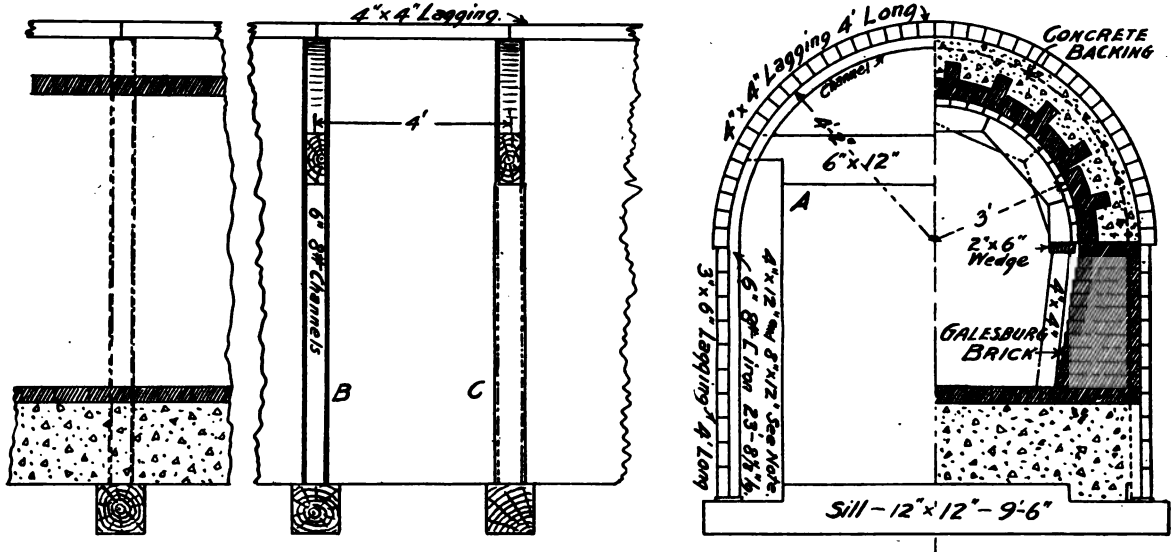
W. C. Whitney, supervisor of bridges and buildings, Boston & Albany:—It has been our practice in the renewal of nearly one hundred bridges in the past three years to erect outside and "roll in" in nearly every case. This work was all done by contract. This method was chosen primarily on account of the very heavy and frequent traffic and also on account of the design of many of the new bridges. In a number of cases the new bridge consisted of longitudinal rolled beams imbedded in solid concrete. These slabs were built in sections about 10 ft. wide and were lifted into place by a derrick car, I-beams or channels arranged with pins at the outer ends to take a cable-bridle being used under the slabs to prevent the cracking of the concrete while being handled.

On the main line the rolling in of a new bridge was almost invariably done between trains, on Sunday, on account of the heavy traffic, this work being done in many cases in as short a period of time as 45 seconds. In the early period of this work the old bridge was supported and the new erected on old rails on top of falsework and the bridge was moved laterally by sliding on these rails which were greased. It was later found expedient to use rollers made of old shafting about 2 in. in diameter. These rollers were placed between double tiers of old rails and were held in place by two 3 in. x 5 in. angles with 2¼ in. holes punched in the 5 in. legs, through which the rollers extended. (This feature is shown in one of the photographs.)

Another interesting feature which developed during the installation of these bridges was the sand jack. When the new bridges are of open steel construction the transferring of the weight from the rollers to the bridge seat can be accomplished by the use of the ordinary hydraulic bridge jack. In the case of large concrete slabs a different method was necessary, as unequal lowering would tend to crack the slabs. For this purpose a sand jack was used which, as originally constructed, consisted of a long trough built of a sill supported on timber blocking. On each side of the sill an 8 in. x 16 in. timber was bolted and the space thus formed was filled with dry sand. The sill of the falsework bent was placed on top of this sand and when it was desired to lower the bridge one of the 8 in. x 16 in. timbers was unbolted and the sand allowed to run out gradually, thus lowering the slab on to the bridge seat. Later a modification of this method was used which gave a more positive regulation of the lowering and allowed the sand jacks to be easily moved from place to place. This consisted of the building of oblong boxes of plank bolted together. The sand was placed in these boxes and supported short blocks of 12 in. x 12 in. timbers on which the falsework sills rested. The lowering of the slab was accomplished by digging out some of the sand with hoes or shovels. When the pressure on the sand became excessive some of it would be forced out from under the 12 in. x 12 in. block and this in turn would be lowered, thus lowering the slab. It was also found that wet sand would work as well as dry, except in freezing weather. These sand boxes are shown in one of the photographs. The photograph of Bridge 112 is typical of a type of construction which has been largely used, plate girders with solid concrete floors replacing old through truss spans.

When renewing steel structures we leave the old floor system in. The following are descriptions of the methods used in two cases recently on the Boston & Albany, the work being done by contract:

Double track bridge No. 125 originally consisted of a center span of through lattice trusses about 107 ft. long and two pony lattice trusses about



TUNNELING THROUGH 50FT. EMBANKMENT AND CONSTRUCTING 6 FT. BRICK ARCH 148FT. LONG. C.&N.W.RY. RADNOR, ILL., 1904.

NOTES.

Put in sheeting and struts at ends of tunnel and excavate for end and wing walls. Excavate tunnel complete supporting sides and roof as shown at A. When excavation is being done, as lagging is put in, ram earth in tight back of it.
Arch to be of brick with concrete backing,- and to be waterproofed with asphalt.
End walls and wings of range rubble stone. Cap, and arch facing - of cut stone.
Arch centers to remain in place at least 36 hrs. after concrete backing in place.
Posts B, under 20ft. emb., and less,- 4"x12" Over 20ft. emb., 8"x12" (C.)

-C.A.L-

90 ft. long. It was possible to replace this structure with a deck plate girder of the same span lengths. The trusses were supported on falsework, the old masonry piers and abutments removed to the new level and new concrete bridge seats and parapet walls built. On account of the lateness of the season when this portion of the work was completed and the possibility of losing this falsework if the ice in the river should break up the trusses were supported on timber cribs built up on the bridge seats. After the ice had passed out of the river, falsework was erected sufficient to support the floor beams midway between the trusses. A single track was now operated over the bridge, the stringers in one span on the other track were removed and the floorbeams were burned off at the center line between tracks with an oxy-acetylene torch. In the space thus formed the new span of deck plate girders, which had previously been all riveted up, was lowered. Following this, single track was operated over this new span, the remaining stringers and other half of the floorbeams were removed and the second span of new girders placed. After this the trusses were taken down and the process repeated for the two remaining spans.

Double track bridge No. 209 consisted of one span of deck lattice trusses, three in number, 148 ft. long. The floorbeams were placed on the top chord of the trusses and were continuous over the center truss. The stringers were rolled beams. In designing the new bridge, it was decided to make it a 2-span deck plate girder structure with a new center pier, which could be done as the only water under the bridge flows in a small channel at the west end. On account of the depth from the rail to the ground at the location of this new pier (65 ft.) it was decided to use a steel bent, composed of two posts and a cross girder, resting on small concrete piers. The old bridge seats were built up with concrete to a higher grade to fit the new girders. On each side of the position of the new steel bent a double bent of timber was built upon which the old trusses were supported. Single track was now operated on the east bound track and the floor system of the westbound track east of the new center bent was removed. The floorbeams were then cut off at the outer edge of the center truss by the oxy-acetylene torch and the old north truss was securely braced. In the space between the north and center trusses the new span of deck girders was now lowered one at a time followed by the bracing. A similar method was then followed in setting the girders on the same track west of the center pier. The pier ends of the new girders were supported on pony bents built up from the main bents between the old trusses. This work was started at 8:30 a. m. on Oct. 20, and the erection was handled so rapidly that the first train passed over the new track at 11:40 a. m. on Oct. 21. Previous to this work the columns and bracing for the new steel bent had been placed, but the cross girder had not been placed on account of interference with the old trusses that up to this time had been left intact. On Oct. 26 the floor system of the other track was removed in that portion west of the new center bent. By this time a sufficient number of the diagonals of the old south and center trusses had been burned off by the torch to provide clearance for the new header girder. This girder was then lowered into the space between the two trusses into approximately its correct position and was held against the new girders of the west bound track by means of slings. The columns that had been previously placed together with their bracing had not been placed in final position but had been left leaning outside of the old trusses to which they had been guyed temporarily. With the header girder now in position these columns were allowed to assume their normal position and were entered between the two webs forming the box girder to which they were firmly bolted preparatory to riveting. With the bent now in final position it was possible to erect the deck plate girders in the east span on the eastbound track, followed by the west span in the same track. The old trusses were dismantled in place, the torch being used to cut them in suitable lengths for handling.

H. T. Douglas, Jr., chief engineer, Chicago & Alton:—The question of whether we put in temporary stringers, etc., is determined entirely by the depth of the excavation to be made and the width of opening needed. If the

material is compact, the depth of the opening say not more than 4 ft. and the width of the opening not more than say 8 ft., we put in a bank sill and stringers under each rail, providing the opening will be nearly closed in. The volume of traffic over the line and the location of the opening, that is, whether trains move at high or low speed, is also another factor. There is no sort of a temporary structure, which can be built with the same economy and which will render the same high efficiency as a pile trestle. Pile trestles for temporary construction work are always greatly to be preferred to frame construction.

When renewing steel structures, if falsework is introduced, it should be designed to carry the bridge and traffic, then the old bridge can be dismantled as is most convenient, taking out, of course, first the floor system before disturbing the trusses. If horses are employed, the new structure should be erected on one side. The old structure should be jacked in the opposite direction onto horses and the new one jacked in place. The old structure may then be dismantled, employing the minimum amount of falsework.

W. F. Steffens, assistant chief engineer, Chesapeake & Ohio:—For bridges situated at a very moderate height above water level, say not exceeding 10 ft., and where conditions permit, the construction of a detour temporary trestle enables the reconstruction of the existing bridge to be carried on under more economical conditions than to attempt to support traffic over the old structure while it is being replaced. In the case of a structure like a large drawbridge, and where traffic is dense enough to warrant the extra expense, a temporary detour trestle may similarly be economical in final results, even though the height above the stream is considerably above the limit previously stated.

For roads of moderate traffic, with streams not subject to loss of falsework by freshets, it may be economical to replace the old structure direct in place on falsework. For roads of dense traffic, and where some doubt exists as to the stability of falsework such that the old structure might be endangered by the construction of falsework, the replacement of the spans by constructing them complete on towers at one side and subsequently rolling them into place is not only indicated for reasons of safety but also for reasons of economy, and in the case of concrete slab floors this method is almost a necessity.

It is advisable to leave the old metal floor systems in place until they are replaced with new work, instead of using timber stringers. The space between stringers left by the removal of the floor beams can be filled with washers. Before undertaking any work of this character it is absolutely necessary that an erection plan be prepared showing the new structure and the old structure on the same drawing, with the position and construction of the bents, and full instructions as to removing or placing the various parts. Often it is necessary to move the stringers from the old bridge to a new position longitudinally to enable them to bear properly on the falsework bents.

Good bracing may be the difference between satisfactory and unsatisfactory falsework construction. For simple trestles diagonal bracing should be bolted to each post and lapped over and bolted to sills and caps. Longitudinal bracing should be used if local conditions permit, making these timbers of sufficient cross section to stiffen the trestle under load. For a double deck trestle with pony bents the construction should be similar with the exception that a line of girts should be placed on each side of the trestle if for single track, and intermediate girts also thoroughly fastened to the posts or to the tops of the intermediate caps if for double track. The pony bents should be braced in pairs longitudinally as well as cross-braced.

Pony bents are preferably attached to the main bents by means of metal scab plates, which should always be bolted and never nailed. The slight additional expense of bolting is more than paid for in the time saved when necessary to remove these bents to place the superstructure. Usually the time is very limited when this operation occurs. Runner timbers or girts should always be used on top of main bents.

O. F. Dalstrom, chief draftsman, bridge department, Chicago & Northwestern:—Our practice is to drive piles first, then cap the piles and place temporary stringers, after which the excavation is made. This procedure leaves the track supported undisturbed on the original bed until the bents are ready to receive the stringers. Sufficient opening can then be made below the track to slip the stringers into place, and the temporary structure is quickly made ready for traffic.

Pile bents are preferred where bents are not too high, and where sufficient penetration to insure stability is obtainable. Pile bents are used up to a height of 40 ft. to 45 ft. above ground, the outside piles of the high bents being battered to give them stability against overturning or lateral displacement. Frame bents are used where the height of bents, and character of foundation would require piles of unusual length, also, where rock or very hard material is at or near the surface. Cribbing is very little used. Places where cribbing would serve the purpose, can usually be handled better and more economically with frame or pile bents.

The standard length of falsework spans is 15 ft., using 8 in. x 16 in. x 16 ft. wooden stringers. When it is to carry heavy traffic for a considerable period it is built up in 13 ft. spans. In falsework for through bridges, it is customary to make the span length the same as the panel length of the new structure, to facilitate the erection of the new floor system. When the span length is greater than can safely be carried on wooden stringers in standard sections, I-beams are used, up to lengths of 30 ft.; beyond that length girders are used. Second hand material is kept in reserve, the necessary beams and girders are selected from the material available and the temporary structure is designed in accordance with the same.

Stringers resting on mud sills at the ends are used in placing pipes, excavating for sewers, tile drains, etc., to a considerable extent. The length of stringers used for such purpose is not over 20 ft., for a height of from 2 to 10 ft., depending entirely on the nature of the soil. Openings of this kind are closed up the same day and not allowed to remain open over night. Tunneling is frequently done in placing cast iron and concrete pipe under fills over 30 ft. high. For such small openings the timbering is made of sets of 8 in. x 8 in. bridge ties, spaced 4 ft. centers, with 2 in. plank logging.

The advantage of a temporary detour trestle depends upon the comparative cost of detour and falsework construction, and the convenience of traffic. The determination depends on a number of factors, such as the size and character of structures to be removed, and those to be erected; the volume of traffic; the space and general conditions at the location of the turnout; the nature of opening crossed, etc. In general, where large and complicated structures are involved, especially those to be erected where the traffic is heavy, and where there are no serious obstacles to constructing a turnout, such a turnout will serve the purpose better than falsework. But such cases are few in ordinary railway maintenance work, and need hardly even be considered unless reconstruction on falsework, under traffic, presents serious special difficulties.

Where the structure to be removed is such that it can be removed without difficulty, and the new structure can be quickly assembled, there is no necessity for building temporary bents for erection alongside the permanent location, and then shifting the completed structure into place. The advantage of such procedure is in cases where there is a great amount of fitting and adjusting of parts and many holes to be drilled and pieces to be cut, as in remodeling and erecting a second hand structure in a new location. This method is also frequently used in erecting through plate girder spans on double track lines with heavy traffic. The whole span can be riveted up without interruption, and sliding the completed structure into place is the work of only an hour or two. Another type of structure to which this procedure can be applied to considerable advantage in erection is the ballasted floor bridge with concrete deck and waterproofing. This allows time for the concrete to become thoroughly set, and the waterproofing to be dried before ballast is applied and traffic turned on the bridge.

ROAD	1. In locations where there has been no opening in the roadbed do you put in strs. and ties first, or drive piles first?	2. Your first choice—piles, framed bents or Chinook where conditions will permit of either?	3. To what depth do you excavate on ea. drift when using frail supports in locations similar to above mentioned	4. Standard length of span for false-work?	5. What is your practice on false-work spans longer than the standard	6. What width and depth of opening limits the use of stringers only, resting on earth at each end?	7. At what depth would you tunnel instead of trestle?	8. What do you recommend for supporting tracks when tunneling process is used?
A.C.&H.B. Ry. 255 Miles R.S.McCarmick Ch. Engr.	piles	Piles	To obtain shoulder for mud blocks.	14 ft.	"Hogs-back" it.	See Letter.	30 ft.	Standard Stringers.
B.&O.R.R. 3473 Mi. F.L. Stuart, Ch. Engr.	Piles	Piles	Never use frame supports when piles can be driven	13' to 17'	Steel	Depends on character of Soil. Figure 1:1 slope	Depends on character of soil &c	Opening large and fairly close to surface Arched timber lagging
Bangor & Aroostok 630 M. M. Burpee Ch. Engr.	See letter	1. Crib 2. Frame 3. Piles	Determine on the ground.	Same as for Permanent, 2/3 as much timber	Use Additional Stringers	10 to 12 ft	Depends on material and kind of Structure	Small tunnel use Stringers. Large - use Piles.
Do W.E. Alexander Supt. B.&B.	Stringers first	Framed bents cheapest	Center to full depth others to Slope	12' to 14'	Use more or larger Stringers	12' wide. 4' to 5' deep	Depends on matl.	Roof timbers and posts from sill.
Boston & Albany. 392 Miles N.C. Whitney Supv. B.&B.	Piles	Piles	Do not use	12 ft. 3-85.16 H.P. under each rail	I-beams or Girders	See Letter	No Experience	No Experience
Boston & Maine 2244 Miles B.F. Pickering Supv. B. & B.	Piles	Piles	No Reply	13' to 14'	Use Intermediate support	4' x 4'	No Experience	No Experience
C.R.R. of N.J. 646 Mi. J.O. Osgood Ch. Engr.	Piles	Piles	Frame bents are kept blocked as as excavn. Progresses	12'	I-beams and Girders	Anything old track drains. Pile bents for end supports	Do not tunnel through fill	Pile and timber trestles.
Cent. W. Ry. 336 Miles C.F. Flint For. B.&B.	Piles	Piles		13'	Additional Stringers	Depends on soil. Not more than 6 ft.	For small tunnel. 10 ft.	Forms made of timber or plank.
C.&O. Ry. 2004 Mi. M.F. Steffens Asst. Ch. Eng.	Piles	Small open crib work. Med. Frame Deeper piles.	4 ft.	16 ft.	I-beams or Girders	4' deep 4' wide	18 to 20 ft.	Support track with piles
C.&A.R.R. 102.5 Mi. H.T. Douglas, Jr. Ch. Eng.	4' depth, 8' opening Strs. other use piles	Piles	Do not use this method	14 ft.	Addn'l strs. or steel	Never use Str. without mud sill.		Same as in mining.
C.&N.W.Ry. 7635 Mi. M. Riney For. B.&B.	Piles	Piles		16 ft.	Steel	16' Str. with mud sills. 8' cut	No reply	No Experience
Do. L.J. Anderson For. B.&B.	Piles	Piles		13' to 16'	18 to 24' use I-Beams. then girders	4' deep	over 20'	No support if properly timbered
Do. O.F. Dahlstrom ch. Dftsmn. Bridge Dept.	Piles	Piles		15 ft. 8"x16"-16' Stringers	I-Beams up to 30' then girders	See letter	30 ft. See letter	See letter
Do. F.L. Burrell For. B.&B.	Small opng. use strs. and Sills	See No. 1	12 to 15'	13' to 16'	Truss	8' deep 10' span	Depends on soil and Size of Structure	Piles when necessary

9.	10.	11.	12.	13.	14.	15.
Do you prefer framed, or pile bents, or grillage in supporting tracks when rebuilding bridges where the bottom permits of framed bents?	Do you recom'd. a detour temp. trestle for traffic or a trestle and existg. Br. to permit dismantling structure & carrying traffic in recons. of Brge. What limit of ht. of trestle do you consider objectionable?	Do you recom'd. bldg. a new Brg. complete on horses on one side, and rolling it in, or supporting the old structure on falsework and rebuilding in place?	When removing steel structures is it advisable to take out the old metal floor sys. replacing with timber or leave until new Br. is ready to be put in when plac. temp. trestle for traffic & dismantle under old structure	In rocky bottom do you use long sills for the whole trestle, or short sills for separate posts, or omit the sills on temporary falsework, where bottom is uneven?	Bracing. Details of for simple trestle. Double deck, with pony bents.	Pony Bents. How attach'd. to main bents, Metal or wood. Bolted or nailed. Use runners or girts on top of main bents?
Piles	Prefer trestle or frame bents under the old structure	Timber in place. Steel at side or end	No experience Prefers Second plan.	Rock Bottom omit sill		
Frame if bottom permits	See letter	prefer to roll in if traffic is heavy	See letter	Rocky bottom omit sills and put braces as low as poss.		Prefer metal scabs with 3/4" bolts
Framed bents	Prefer temp. trestle under bridge	Prefer to build in place.	Leave old floor System	Rocky bottom omit sill	No Reply	Scab plates or dowels Girts on top of main bents
Framed bents where no danger of being washed out.	Depends on Conditions	Small bridges roll in. Large in place	Depends on Structure	Rock bottom no sills If posts may settle use short sills	2 cross braces bolted. L. in every span. L. Girts.	Bolt scabs
See letter				Short sills		
Pile bents	Conditions will not permit of detour on this road	Rebuild Under traffic	Usually done by Contract	Omit sills	No reply	No reply
Pile bents	Use detour method when practicable	Use both methods	See plan	Use long sills or omit sills entirely	See plan	See plan
Pile bents	Do not practice this	Short spans		Omit Sills	X Braces	Wood scabs bolted. Runner timbers
Framed bents	see letter	See letter	See letter	See letter	See letter	See letter
Piles	No 60 ft. trestle	Determined by local Conditions	See letter	Omit sills		
Crib filling with rock & placing frame bents		Plate Girders Roll in	Leave in old floor		4"x10"	
Framed bents Cheapest	Do not favor detour as a general rule 40 to 50'	Roll in if possible	Remove old floor system	Rock bottom Sills not needed	Under 20' Stray bracing, each bent braced and all tied with girts	Toe nailed Use girts on top of main bents
Frame bents if long Piles needed or rock bottom	See letter	See letter	See letter	Short sills	see plans	See plans
Framed bents		Depends on traffic	Leave in old.			

ROAD	1	2	3	4	5	6	7	8
C.C.C.&St.L. 1830 Mi. G.P.Smith Ch. ENGR.	Piles	Piles	Do not use this method	15 ft.	Add strs. up to 20' Use 10 pc. 8"x16"	4' wide 6' deep	30 ft. for small tunnel say 5' square	Timber frames and poling boards
C.R.I.&P. 7574 Mi. M. Bishop Mast. Carp.	Piles	Piles	Do not favor this method	15 ft.	Metal	Depends on nature of soil Do not favor this method	No experience	No experience
D. & H. 862 Mi. G.H.Burgess Ch. Engr.	Piles	Piles	Excavate so slope of 1/4:1 in ord. Matl.	6 pc. 8"x16" 12' span	Steel girders or I-Beams	12' clear span 4 ft. deep Sides 1/4:1	Dep. on nature of matl. & comparty. cost of trnl. & tunnel	Tim. frame wrk. for tunnel Cov. with lagging. used as support.
D.L.&W. 985 Mi. G.E.Boyd Supt. B&B	Piles	Piles	Depends on local cond'as.	12' Mainline 15' branch 3 ply, 8"x16"	Add Stringers or use Steel	5 to 6 ft.	Depends entirely on character of fill	Depends on size and depth below tie
D.&R.G. 2598 Mi. J.G.Gwynn Ch. Engr.	Piles	Piles	To hard ground Local Cond'as. govern	8-10"x30-32" Fir on sills with heavy floor. whet. sills	Nothing longer than 32 ft.	Any depth when 1:1 from edge of floor under sills or bot. of built head	12 ft. if material permits	Tunnel more than 5 ft. Use Strs. as in No. 4
ERIE 2258 Mi. R.C.Falconer Supt. Const.	Piles	Piles	Use only in rock & then rock until bath reached & put in Frame bent	12 ft. Center to Center	Increase No. & size of Strs. up to 16 ft. over- use Steel	Do not use excp. on small opening	See letter	Timber tunnel excavation
F.E.C.Ry. 580 Mi. E.K.Barrett Supt. B&B	Piles	Piles	Framed bents not used	10 ft.	Addnl. Stringers or Steel	8 to 10 ft. on shallow opngs. with mud sills	Dep. on nat. of fill, size of opening, and relative cost	Supports that are needed to hold tunnel roof.
G.R.&I. 587 Mi. E.H. Barnes Ch. Engr.	Piles	Crib work if possible	Do not use	16' span 3 pc. 10"x18" under ea. rail	I-Beams	See letter	10' summer 6' winter	See letter.
G.C.&S.F. 1063 Mi. F. Merrill, Ch. Engr.	Piles	Framed bents		14 ft.	Extra Stringers		No preferinc.	
I.C.R.R. 4755 Mi. A.S.Baldwin, Ch. Engr.	Piles	Piles	Do not follow this practice	14 ft. 6 pc. 7"x16"	8-7"x16" 16' span 10-7"x16" 18' span Lumber are I-Beams	Depends on character of ground	Depends on relative cost of two methods	Frequently use old ties
Do F.O.Draper Supt. Bridgs	Piles	Piles	To Surf. of ground	14 ft.	16 to 20' 5 ply Stringrs.	16 ft.	16 ft.	
INTCOL'NL. 1468 Mi. A.E.Killan Gen. Inspr.	Piles	Piles	2' to 3'	8' to 12'	Add strs.	7' to 9' wide 6' to 10' deep always use 30 to 35 stks.	25' up	See letter.
I.&G.N. 1106 Mi. O.H.Griffenden, Ch. Engr.	Piles	Piles	Dep. on matl. If firm go as deep as 8	14 ft.	Increase Chords	14 ft.	No exp.	No exp.
K.C.S. 840 Mi. J.J. Taylor Supt. B.&B.			To nat. Surface of ground	22 ft.		6' wide 8' deep	Over 10' deep pipe not to exceed 48" diam.	
L.I.R.R. 339 Mi. J.R. Savage Ch. Engr.	Piles	Piles	Do not follow this practice	12 ft.	Steel girders or I-Beams	Depends on Circumstances	Never done	Recommend supporting tracks relvg. tunnel roof
L.&N.R.R. 4740 Mi. R.O. Elliott Supv. B.&B.	Piles	Piles	Used only where could not get 6 ft. pentrn. for piles	12 ft.	Add Stringrs or use I-Bms. or girders	Put Stringrs on cap or bearing Piece	30 ft. and up	Piles and standard false work deck.

9.	10.	11.	12.	13.	14.	15.
Framed bents	Trestle under existing bridge	Roll in only when density of traffic requires.	Leave in old floor system	Omit sills		Wood scab plates. Use girts
Pile bents	Detour trestles in certain locations	Depends on cost and conditions	In most cases not necy to replace metal floor with timber.	Any method depends on conditions	No answer	
Framed bents	Detour tres. when height does not exceed 20'	Build in place if traf. permits When tr. heavy erect outside & roll in	Leave in old floor system	Short sills	Brace on ea. side of bent. Long. braces in every other bay.	Scab plates nld. or bolted. Runner timbrs on top of main bents
Prefer pile: have used frame and grillage	Depends on locality and character of traffic	Same as for No. 10	No Answer	Prefer long Sill		Bolt scab plates. Girders on top of main bents
If ground is hard use Sills and blocking	No; build trestle 40 ft. high	Girders set on temp. bents. Put in place with crane	Support old floor system Take out old floor and put in new.	Use long sills & level up with blocks Bare foot posts not safe	Up to 16 ft. bents 2 braces	Scab and bolt Timber girts
See letter	See letter	See letter	See letter			Wood scabs bolted. Use girts on main bents
Framed bents.	Ordinarily prefer trestle under existing bridge	Girder deck spans roll in. Thru pin con. & riv. roll in	Leave old floor system if possible.	Engineer's Judgment in each case	No answer	Prefer drift bolts to scab plates.
Frame bents.	See letter	See letter	Remove all old first See letter			Bolted Use girts
	Prefer detour if cost not too much in excess			Rock bottom omit sill		
Pile bents	Never used detour trestle	Frequently use first method	Ordinarily leave old metal floor system in place	Omit Sills	Brace on each side of bent	scab plates and bolts.
Piling	Do not recommend Detour trestle.	Only roll in in certain cases.	Floor sys. shld. be removed when falswk. put in	Long sills anchor bolted to stone		
Pile bents	Ditto above	Never rolled in spans.	Never used falsework to erect new spans.	Omit Sills.		
Pile bents	Trestle under existing brdg. All heights	Gently support old on falswk rebuilding in place	Remove old if new is Girder type	Long sills.	Sway and Longitudinal bracing.	Scab plates bolted or nailed Timber girts.
Piles.	Trestle under exist'g Br. 40 ft.	Rebuild in place on falsework.	Leave in old floor system	Omit sills and brace well	Sway brace bents under 18 with 4x10 over sash brace & sway	4"x10" scab plate spiked
Piles	Depends on volume of traffic.	Girder spans roll in Trusses build in place	No experience	Depends on character of bottom & velocity of stream	Simple X for short and double X for high	Metal scab plates bolted to bents.
Pile bents	Would seldom detour Limit 15 to 20 ft.	Some cases, roll in	Leave in old floor system	see letter		See letter

ROAD	1	2	3	4	5	6	7	8
MAINE C. 1180 Mi. B.T. Wheeler Ch. Engr.	Tempory strs. and ties first	Piles	Do not follow this practice	12½ ft.	Use addn'l. string'rs.	15 ft. with strs. resting on emb. at each end	Rarely used No stand.	old ties
MICH CENT. 1817 Mi. G.H. Webb Ch. Engr.	Piles	Piles	6 ft.	15 ft.	I-Beam	Method depends on each case	16 ft.	Sheeted and braced
M. & ST.L. 1536 Mi. E. Gagnon Supv. B. & B.	Stringers. prefer sht. piling to piles	Crib inside of bents when traf. is light	7 ft. to 10 ft.	14 ft. 6-8"x16"		Must have 6' to 10' bearing the cross plank under ends of strs.	30 ft. up	Use 8"x16" or 12"x12"
MR & BT 64 mi. C.H. Fake Ch Engr.	Piles	Piles	Depends on Material	12' to 20' Usually 14 ft.	Girders	8' to 12' W 6 to 8 ft.	When too deep to drive piles.	Depends on Individual case.
MO. PAC. 7239 Mi. C.E. Smith Ch. Engr.	Piles			14 ft.			40 to 50 ft.	No support at 50 ft. depth.
N.C. & ST.L. 1233 Mi. H. McDonald Ch. Engr.	Piles	Low fills crib wk. High fills pile bents. Also dep. on cost	Do not use this method	12 ft.	Add Strs.	12' wide 4' deep	When depth of fill is more than twice the span	Stringers under trk. ties.
N.Y.C. 2829 Mi. E.E. Wilson Supv. Brs.	Piles	Piles	Do not use	12 ft.	I-Bms. or Girders	Always use mud sill. 8' wide 4 to 6 deep	Dep. on local condn. 40' to 50'	If in earth fill timber the tunnel
NYNH & H 2091 Mi. W.H. Moore Brdg. Engr.	Stringers then piles	Piles	Crib and excv. to within 6" of bottom of sill.	12 ft.	2nd hand I-Bms or Girders	8' wide 6' deep 2 mud sills at ea. end	20' to 25'	Steel on piles outside limit of tond. falsework
Nor. Pac. 6233 Mi. J.C. Taylor Supv. B. & B.	Piles	Piles	20 ft.	16 ft.	Inc No. of strs.	Is not permitted	20 to 25 ft.	
O.S.L. 1762 Mi. A.H. King Supv. B & B	Piles	Piles	Dep. on time bet trains.	No Standard	Add Strs.	No rule	In loose dirt or grd. formation at 15 ft.	No support except tunnel lagging
P.M.R.R 2330 Mi. A.L. Gravdy Ch. Engr.	Piles	Piles		14 ft.	Steel	12' wide 10' deep		
"Do" J.D. Black Supv. B. & B.	See letter	Piles	See letter	14 ft.	Deck girders	10 ft.	20 ft. and up	
P. Lines W. 3098 Mi. Thos. Rodd Ch. Engr.	Piles (See letter)	Piles	Do not use	No Standard	Steel	15 ft. Dep. on ∠ of repose of Matl.	20 to 30 ft.	Timber bents and plank lagging
P.C.C. & St.L. 3098 Mi. S.C. Bowers M.C. Brgs.	Piles	Piles	Do not use this method	14'-8"	Up to 26" use I-Bms. Over 26" girders	Do not exceed 8' in main line work	Dep. on matl. of fill & size of opening	see letter
Q. & C. 707 Mi. C. Dougherty ch. Engr.	Piles	Piles	Dep. on local Condns.	Determind. by local needs	See ans. to No. 4	Do not use Construction indicated	See letter	Broad bearing to prevent set. Element of track.
C.R.I. & P. 7547 Mi. W.W. Parker For. B. & B.	Piles	Piles	Do not favor this method	20 ft.	Add Strs. or steel	Loose fill 15' openg. 5 to 10 ft deep	10 ft.	Pile bents & Stringers

9	10	11	12	13	14	15
Framed bents	Seldom use detour trestle	No gen. rule Recom. rolling in where feasible	Leave in old floor system wherever possible.	Omit sills when height of trestle is moderate.	Thoroughly braced	No standrd. practice on pony bents.
Framed bents if rock, otherwise piles	"A" cheapest "B" 40 ft.	In place if traffic permits otherwise outside	Leave old system if plan permits	Long sills evening up with short	"A" 3" x 10" X bracing. "B" Long br. in alt. panels.	"A" bolted to main bents "B" Girts.
Frame bents quicker.						
Frame if more convint. unless danger from flood	Detour trestle.	Roll in when traf. is dense if not-lower girder in place	Depends on style of old & New.	Depends on bottom	No reply.	No reply.
See letter			See letter			See letter
Framed bents	Have never found it advisable to use det. trks.		Leave old floor System	omit sills	Wood. scab plates nailed	Yes
Framed bents	Detour when traf. is livy. Deps. on local condns.	Roll in when squire, & less than 100 tons	Usually take out old floor.	Short sills, or none		Wooden scabs bolted
Pile bents	Detour if erection is complicated "B" 45ft.	Erect in place	Leave old floor System	Low trestle use short sills High, - short undr. are long	3"x10" bolted up to 18' above that put in hor. brace & 2x br.	Runners notched over caps of lower bent
Frame bents if stone bottom	Trestle undr. existg. Br. 75' to 100'	Supporting old struct. on fals-wrk.	Remove old floor system	Rock bottom omit sills & use blocks	No answer	Use boat spikes with nailing piece. Use runner thru.
Pile bents first	Local condns often require detour. Final cost skid. decd.	Roll in if possible	Leave in if possible	Long sill filled in with shorter ones.	Sway brace on ea. side	Timber scabs spiked, and Sometimes bolted
		On steel girders roll in				
Pile bents	Recommend detour 24' Limit	Trusses in place; Girders, roll in	Leave in old floor system	Omit sills and low brace		
Piles	Depends on Volume of traffic	Depends on Vol. of traffic & other condns	Leave old floor System	Use sills unless bottom very irreg.	3"x 10" X-braced	"A" wood scab plates. "B" runner thru. bolted to top of main bents.
Pile bents	Would not detour	see letter	see letter	Continuous sills if pos.		Iron scabs bolted. Use girts
Pile bents	Depends on mkt. Not used on account of cost	Prefer to roll in when cost is not much greater	No fixed practice	Depends on local Conditions	Strong as standard trestle	Runner timber or girts
Pile bents	Detour temporary trestle	No. Ans.	Leave in old floor	Omit sills and use sash brace		

ROAD	1	2	3	4	5	6	7	8
S.L. & S.F. 4749 Mi. F.G. Jonah Ch. Engr.	Piles	Piles	6 ft. if matl. would permit	14 ft.	Make span 28 and use 6 strs. per rail	18' wide 8' deep	Nature of matl. & size of opening	Shore with timbers
S.L. S.W. 1451 Mi. C.D. Purdon Ch. Eng'r.	Piles if opening over 6' or 7 ft.	Piles	12 in. to 18 in.	15 ft.	Use addn'l. Strs.	7 ft.	Depends on kind of openg.	Excav. on ea. side with perp. matls. Line with crib wk. or sheet piling.
Santa Fe 5848 Mi. J.F. Parker Gen. For. B.&B.	Piles	Piles	Do not use this method	Variable	See letter	6 to 7 ft. deep	Depend on fill	Piles
S.A.L. Ry. 3070 Mi. W.D. Faucette Ch. Engr.	Piles	Piles	Depth depds. on char. of ground	No standard	Steel	Depends on char. of matl.	No data	No data
Sou. Pac. 6368 Mi. D. Burke Supv. B.&B.	Piles	Piles	15 ft. by keeping up a good bulkhead	15 ft.	Add Strs.	15' wide 20' deep in good earth	20 ft.	Bents and lagging
"Do" J.G. Replogle Supv. B.&B.	Piles	Piles	Do not use this method	15 ft.	Increase No. of Strs.	8' wide 4' deep	Depend on kind of app. size, & matl. in fill.	Lagging prop'ly shored and braced
"Do" W.S. Corbin For. B.&B.	Piles	Piles	4 to 8 ft.	15 ft.	Truss span	Not any	Dep. on ground and amt of matl. expected	Temporary timbering
SOUTHERN 7036 Mi. B. Herman Ch. Eng. M. of W.	Piles	Piles	Do not follow this practice	On temp. work & slow speed, 15". 3-7"x16"		Dep. on soil. Use mud sill & blocking	25 ft.	Tunnel. If piles needed to support trk. use open cut.
T.&B.V. 455 Mi. B.M. Hudson G.F. B.&B.	8' or less, Sills + Strs. 8' to 15, piles. 15' up, - Tunnel	Piling	8 to 10 ft.	14 ft.	Reinforce chord & reduce speed	8' x 8'	15 ft.	Tunnel timber
W. Pac. 934 Mi. M.R. Krutsinger Supv. B.&B.	See letter			30' span	Trusses over 30, as 30' is limit for blocking	16' deep 20' at top	All depths over 16 ft.	Timber and lagging in Tunnel

The simplest and most economical procedure is to leave the old floor system in place, supported on falsework, until replaced by the floor system of the new structure. With this procedure in view the temporary structure can be designed in such manner that the old floor system can be replaced, panel by panel, by the new floor system, without inconvenience to traffic or difficulties in erecting. The old floor system may be carried directly on the stringers of the temporary structure if the bents can be located properly with reference to the panel points of the new structure.

If the panels of the new structure are longer than can be permitted for the spans of the temporary structure, or if, for any reason, the bents of the temporary structure can not be properly located with reference to the panel points, the old floor system can be carried on blocking on a system of sub-stringers. The procedure of erection is not materially different from that in the other case, but there is more material in the falsework of the sub-stringer type.

Long sills under an entire bent are hardly ever practicable. A short sill under each post provides a ready means of bringing each post to bearing, and adapting the bent to the irregularity of the bearing surface.

R. C. Falconer, superintendent of construction, Erie R. R.:—We generally support the track on piles and stringers, but where the embankment to

9	10	11	12	13	14	15
Frame if no danger of washouts	Prefer trestle under existg. bridge. 75' if needed	Drop girders in	Put in new as old floor sys. is taken out	Omit sills & use heavy sash bracing	Sway 3x10 long. 6x10	Pony bents drift bolted
Piles	Do not recommend detour trestle	Horses on side for new steel girders	Leave old floor System	Depends on character of bottom	"A" 4x10 bolted "B" Same as above on each deck-like cross braces	Wood scab plates
Framed bents	Detour trestl. under heavy traffic 10ft. limit.	Low bridge roll in	No experience	Short sills or omit if rock bottom. Use low braces	Sway brace over 6' high and sash brace every 12 f.t.	Drift bolt or toe nail Use girts on top of main bents & cap on pony =
Framed bents	Depends on safety, cost & expediency	Prefer to roll in when pos.	Leave old floor System	Rocky bottom omit sills & put brace as low as pos.	Sash and diagonal braces	Scab plates either wood or metal
Pile bents.	Detour on heavy traf.; 5 60 to 65	Build in place except small gir. Use gallows frame.	Remove all old except floor system	Short sills and blocks.		
Pile bents	See letter	Rebuild in place	See letter	Short sills Posts well braced	See letter	See letter
Pile if Possible	Detour if possible	Rebuild in place	Only exp. in new work; not under traffic	Long Sills.		
Piles	Do not use detour trestle	If can be handled with derrick build outside	Leave old floor System	Omit sills and put brcs. as low as possible	2–3x10 bolted	Drift bolted
Frame bents	Always trestle in place	If girders, and traffic heavy, roll in	Leave old in	Short Sills		
Frame bents		No experience in rolling in	Leave in When panel lengths are the same			Drift bolt

be tunneled is old and more compacted, we might tunnel when the depth of excavation would be 40 ft., and there was 25 to 30 ft. of material over the top.

When traffic is heavy and frequent and local conditions permit, our general policy is to erect the new bridge alongside the old bridge, and to slide the new into place, and the old out, simultaneously. One reason for doing this is that it eliminates the necessity of maintaining a slow order for any appreciable length of time, and makes working conditions for the bridgemen less dangerous. If, however, there is to be an appreciable change in the elvation of the tracks at the time the bridge is renewed, or if foundations of movable bridges are to be rebuilt, we use a temporary trestle on which to detour traffic. Where traffic is not very heavy or frequent, we prefer to use the first method, unless the cost of erecting the bridge under traffic would be more economical, or the design of the old and new bridges would not permit the old bridge to be moved out, and the new bridge shoved in place, after being erected on the side. The height of tracks is not a governing feature in either case.

When traffic is such that there are intervals of 1½ hrs. between trains I would advise leaving the old floor system in position until the new floor is ready to install. Otherwise I would recommend revising the old floor system and using wooden stringers of such length and so arranged to accommodate the new panel lengths of the bridge.

E. H. Barnes, chief engineer, Grand Rapids and Indiana:—At locations where there have been no openings in the roadbed, the method of procedure would be governed by the kind, size and depth of the permanent structure for which temporary work is required. Assuming that a temporary trestle is required, my practice would be to first drive piling, then cut off and cap at the proper height and put in stringers and ties. I consider this plan the best for the reasons: that it permits of placing the piling so that the load on the caps will come directly over the piling; it saves time in driving piling, the only obstructions in the way being the rails and ties; it causes the least disturbance of the track and thereby less delay to traffic, and where it is necessary to raise the grade it permits of doing so with the least amount of blocking, as the piling can be cut off at such a height that the top of the caps will be against the rail thereby permitting a gradual raise of the grade when placing stringers and ties.

My experience has been that the character of fill entirely governs in this form of temporary work. An opening 2 ft. wide at the bottom and 6 to 7 ft. below the base of rail is approximately a maximum opening for a muck or sand fill, while in mixed clay and gravel, one can excavate to a depth of 8 ft. and in heavy dry clay, to a depth of 10 ft. Through heavy clayfills an opening large enough to put in a 2 ft. iron pipe can be made with safety at a depth of 8 ft. without any supports under the tracks. At greater depths, openings large enough for 5 ft. sewer or iron pipes can be made. In muck, sand or mixed gravel fills, the tracks should be supported with temporary stringers under the ties and the opening made through the fill by the use of props and shores with plank along the sides and top, the plank to be drifted in ahead of the excavation.

J. J. Taylor, superintendent of bridges and buildings, Kansas City Southern:—When introducing 10, 12, 16 ft. and larger arches where a 22 ft. center to center panel of falsework will not give sufficient clearance, we run up the two bench walls, provide a landing about at the haunch line just outside of the inside circle of the arch and introduce frame bents on top of the masonry at each bent wall to span the masonry while the arch is being turned, which are left in until the opening is filled.

We recommend supporting tracks by cribbing a tunnel, laying 3 in. x 12 in. timbers at right angles with the track in the bottom of the tunnel on each side of the excavation and setting on top of this, uprights not less than 3 in. x 8 in. if handy, of any kind of second hand material available and strong enough. We cross the same on the top with nothing less than 3 in. material for an opening 6 ft. in diameter and heavier material in like manner for a larger opening.

C. E. Smith, assistant chief engineer, Missouri Pacific System:—It is my invariable practice to drive piles before putting in temporary stringers. I have never put in stringers first where it was known that piles would be used, for they would be in the way of pile driving and would later interfere with sawing off the piles. On account of the cut-off of piling being about 3 ft. below the rail it may be necessary in such cases to bridge over the pit that is dug for sawing off the piles, but this can easily be done by throwing a few short pieces of blocking under the track ties.

The choice between piles, framed bents and crib work will depend on the amount of traffic. Where the traffic is light and the excavation is made to a considerable depth, or where the bottom is of a rather soft character and deep excavation must be made I would certainly drive piles. An exception to this would be made in places where the ground was of such hard material that piles could not be driven sufficiently deep to carry traffic after excavation, or in places where the traffic was so heavy that very little work could be done on the track by a pile driver. In either of those cases crib work under the stringers gradually leading up to frame bents would be my preference.

The depth to which excavation would be made depends on the character of the material. In general, I would excavate as deep as the material will stand with safety. Assuming bents spaced 16 ft. between centers, there would

Sand Jacks Used on Boston & Albany R. R.

be a bench about 8 ft. wide to support the blocking and it should be possible to go down from 4 ft. to 6 ft. with safety. At such an excavation and in extra good material on light traffic lines, greater depth might be obtained.

Where falsework spans are longer than the standard, the unit stresses are kept below 2,000 lb. per sq. in., and in case the span is over 24 or 25 ft. long, I-beams or deck girders are freqently used.

The limiting width and depth of opening will depend on the character of the material, but if the material is firm I see no reason why excavation can not be made to a depth very nearly equal to the clear span between the blocking. The excavation can be carried to a considerably greater depth by the use of sheeting and struts. As a rule I would tunnel instead of trestle at a depth exceeding about 40 or 50 feet. At that depth I would not support the tracks in any way but let them run on the fill. I would make an effort, however, to completely fill the excavated space so that there would be little tendency for later settlement of the fill.

When rebuilding a bridge, if the bottom is rock or other firm material at a location not subject to scour or wash, I would prefer the use of frame bents; but as a rule in this section of the country, a bent placed in running water will cause considerable scour, which would make unsafe the use of frame bents in running water. They should not be used where the bottom is so wet that the material can be squeezed out from under the blocking, thereby causing settlement. In all possible locations, however, I would prefer the use of frame bents and in some places I would use frame bents on top of driven piles where the height was sufficient.

There will be many places where local conditions will compel the construction of a bridge under traffic or the construction of a bridge to one side to be rolled in during a short interval of time; such locations being in con-

Changing Spans, Bridge No. 112, B. & A. R. R.

gested districts where there is no room to construct temporary trestles on the side. In any case I think it is a matter for close estimate as to whether the expense of a temporary trestle and the necessary track changes is warranted by the amount of traffic and the reduced cost of construction. On light traffic lines it will very rarely result that temporary trestles are justified. I do not think the height of trestle alone would be the governing condition.

Where it is important that traffic be not delayed during the construction of falsework and the reconstruction of the bridge it will become necessary to construct the bridge off to one side and roll it in. On light traffic lines the cheaper method invariably is the reconstruction of the old bridge on falsework under traffic.

Preferable practice would appear to be the substitution of the old floor system by the new floor system as soon as possible. If the design of the two floors and of the falsework (which latter in some cases must be specially designed to favor the work) makes the change convenient considerable economy will result in changing the old steel floor directly for the new, thereby eliminating the trouble and expense of putting in the temporary floor.

Where possible, long sills are used on uneven bottom for a whole bent, although in some cases where the bottom is very rough and irregular posts may be stopped at different levels. As low down as possible, however, in such cases there should be double sash braces extending the full length of the bent in order to hold all the legs together. In cases where the sash bracing can be put on near the bottom, I would have no objection to omitting the sills entirely on uneven bottom.

As a rule, in the bracing of falsework, an effort is made to avoid the use of boat spikes or other fastenings difficult to remove and the removal of which would cause damage to the timber. If the braces are bolted to the posts there will be little difficulty and practically no loss of material in their removal.

Changing Spans, Bridge No. 209, B. & A. R. R.

S. C. Bowers, master carpenter of bridges, Pittsburgh, Cincinnati, Chicago & St. Louis:—When tunneling for small structures, as for 36 in. pipe, 3 in. material is sufficient for carrying the embankment. For larger structures, at a greater depth than 20 ft. from the base of rail to the top of the tunnel, we find old bridge ties, stringers and car sills satisfactory.

The advisability of building a new bridge complete at one side depends upon the type of bridge and the amount of traffic over it. If a riveted truss is to be installed it should be erected on one side wherever possible, to insure keeping the proper camber in it. Where a riveted truss is built on the same falsework that carries traffic there is more or less deflection and it is almost an impossibility to retain the camber. For a pin connected truss the conditions are entirely different.

J. F. Parker, general foreman bridges and buildings, Atchison, Topeka & Santa Fe:—I have just completed putting in a double 20 ft. arch with 8 ft. bench walls. In supporting the bridge for this work I drove a false bent where the wall between the two arches would come, also another false bent outside of the foundation of one barrel and spanned this opening with 34 ft. girders which we had on hand. For the other barrel of the arch I drove a false bent where it would come through the crown of the arch and another false bent outside of the foundation. This opening was spanned with stringers, as I had girders enough to span only one opening. In building the crown of the arch a tapered opening was left around the bent that came through the crown of the arch, level shoulders were built on the concrete work on each side and frame bents were erected on these shoulders to support the spans so that the piling could be taken out and the opening in the concrete filled. The bent that was driven where the center walls of the arch came was built around with concrete and the piling was left. The center wall between the

Rolling in Bridges on Boston & Albany R. R.

two arches was built 1 ft. thicker on account of the piling being in it. No damage whatever was experienced to the concrete by vibration of this bent.

M. R. Krutsinger, supervisor bridges and buildings, Western Pacific:—Where the ground is stony, as on a hillside, I use a series of short sills for supporting the bent. I have built bridges in the mountains, for standard gage main line, where in one bent, one batter post was 28 ft. long, while the other batter post was 90 ft. high, being built in four decks.

RECOMMENDATIONS.

In concluding this report the committee feels that it is proper for it to make certain recommendations as to the best and safest way to perform work covered by this report in actual practice.

The committee recommends that piles be driven before stringers are put in, as they can be driven so that they will be directly under the stringers and will not have to be pulled or jacked into line; the fill under the track is not badly disturbed when putting in caps and only a small amount of blocking is needed to keep the track safe for full speed of trains at all times, and the work of placing stringers is made easier by having caps in place to slide the stringers on.

In cases where there is a choice of piles, framed bents or crib work the committee would recommend that as a general rule piles be used.

In places where the bottom is soft or uncertain, or where there is the slightest chance for scour by water, the committee would recommend that piles be always used, and that they be driven, if possible, at least 4 ft. below the bottom of the proposed excavation.

The method of excavating on each drift when using framed supports in locations such as the above as already stated does not appear to be favored

by many members and the committee feels that no definite recommendation can be made, as the safe depth very largely depends on the character of the material in the roadbed and the time available for work between trains.

The committee would recommend that where local conditions permit, the span length be the same as the standard trestle span, which will permit of using stringers from stock, and in many cases second hand material can be used.

On spans longer than safe timber stringer construction the committee recommends the use of I-beams or girders.

The committee recommends that whenever stringers only are used they be supported on cross-sills at the ends, except when the width of excavation is to be small compared to the length of stringer. As a general rule the depth which can be excavated is such that a 1½ : 1 slope from each side of the bottom of the excavation will not undermine the sills under the ends of the stringers. This can not be given as a rule to be always followed, as in some soils a 1 : 1 slope would be safe and in others a 2 : 1 slope would be unsafe.

The replies to the two questions regarding tunneling under tracks as already stated, show such a diversity of opinion among the members and others, and there was so little actual construction experience reported that the committee prefers to leave these two questions without any definite recommendations, hoping that in the discussion of the reports at the convention some valuable information will be obtained.

The committee recommends the use of piles, rather than framed bents or grillage, as a general rule, as being safer.

The committee recommends the use of a detour trestle when a suitable alinement of track can be obtained and the cost of this method will not be materially more than of a trestle in place.

The committee recommends the method of rolling in a bridge when conditions will permit, and the expense is not materially greater. In cases where it is not possible to roll in and the new bridge must be rebuilt in place, the committee recommends that whenever possible the old metal floor system be left in and that the falsework be designed with this in view.

Where the bottom is uneven, the committee recommends that short sills be used when possible, unless the bottom is rock, in which case the sills may be omitted entirely; in either of these cases care should be taken to have all bents well braced, with crossbraces as low as possible.

The recommendation of the committee on the question of bracing is that the standard trestle plan be followed in detail as far as possible.

The committee recommends the use of wooden scab plates on temporary work, securely spiked or bolted; it also recommends the use of runner timbers or girts in all cases at every break in the uprights.

W. C. WHITNEY, *Chairman.*
J. B. SHELDON,
J. P. CANTY,
G. ALDRICH,
Committee.

DISCUSSION.

(Subject No. 8, Temporary Structures for Supporting Tracks, etc.)

Mr. Schall:—Mr. President, in the second paragraph I notice that this false work is to be made so that it can be used under full speed at all times. I think that is going a little too far.

Mr. Reid:—I think the question of maintaining full speed

over false work is a point worthy of consideration. On the Lake Shore it is essential to maintain full speed on the main line wherever it is possible to do so, and all of our false work is put in with that end in view. It is not always possible to maintain full speed, but where we can we do so, even if the false work costs more. Within the last two or three years we have had several cases of almost every kind mentioned in the report, and we now have under way several subways where we are maintaining full speed in most cases. In one or two we have speed restrictions. One subway in Sandusky is under seven tracks. It is about 12 ft. down through a stiff earth formation to rock. We drove the piles down as near as we could get them to rock and then did the excavation, replacing the piles, many of which were broken, with independent posts or frame bents, as the excavation proceeded. When all of the pile bents on the one side had been replaced with framed bents resting on the rock, we channeled down through the rock about 8 ft. and put in a deeper set of bents. With that set of bents we will excavate for the abutments and piers. We have to drill and blast the rock, as it is very hard. It will require three sets of bents to get down to the final depth. We had a similar case at Cleveland where a subway was built under six tracks. This subway is under quite a sharp skew on a Y in one of the principal streets in the city. Here it was 5 ft. down to rock. We took two of the six tracks out of use, excavated to the rock, put in blocking and double deck stringers on the blocking, using 21 stringers, with the joints in one set of stringers half way between the joints in the other. The blocking was under the lower set of joints. After we had the stringers in place we channeled down through the rock under the middle of the panels as low as we could safely go under the first set of blocking, put in our first set of bents and removed the blocking. We then went down about 8 ft. further to the second set of bents, put those in all the way through, then finished the excavation of the rock and put in the piers and abutments. We have another case under construction at Erie, where we have 7 tracks. Here the underlying material is sand and hard pan. We used piles there, driving them down as far as we could. After the excavation had proceeded as far as safe we replaced all broken piles either with new piles driven further down, or with posts where we could not drive piles. We have a double track subway at Ashtabula, which is being built in the same way. In all these

cases we are maintaining full speed for all trains, including the Twentieth Century limited, which crosses these trestles at anywhere from 60 to 100 miles per hour.

Mr. Riney:—While temporary structures for falsework on all main lines should be built carefully enough and sufficiently strong to carry traffic at full speed, it is not always policy to permit trains to run at full speed during working hours, as a matter of safety. Men can not work to advantage nor handle material economically when they have to be on the lookout for trains operated at full speed. It may be all right on certain structures and under special conditions, while in other cases it may be wise to limit the speed to a very considerable extent. We build our falsework fully as substantial as the ordinary temporary trestle construction which is perfectly safe to carry trains at full speed, but we seldom permit high speed when workmen are engaged on the structure.

Mr. Whitney:—The committee hoped that there would be some present who could give us some information regarding tunneling under tracks on 30 or 40 ft. fill, especially regarding the method that had been used in actual practice.

Mr. Reid:—We had a case of that kind a couple of years ago. One of our stone culverts gave out,—at least the roadmaster thought it had given out,—and got the chief engineer and other officials scared and made it so uncomfortable for the bridge men that we had to get busy. That fill was 40 ft. high under one of the main tracks. It was too deep to excavate and we tried tunneling. We used second hand ties for our tunnel work, placing uprights on each side and cross-ties on top. We made a sort of half lap joint on each corner, so that the uprights could not crowd in, and the top pieces could not go down. We tunneled through 180 ft. of embankment in that way and found that the old stone box was about 15 ft. wide. We didn't get it all out but got out enough to put our tunnel through and replaced the culvert with a 48 in. cast iron pipe, 108 ft. long. We did not disturb the track at all; did not have to reduce speed and it did not take a particularly long time. Of course, it is a good deal of work to remove 180 ft. of an old stone box, but we did it without any disturbance of traffic and with no serious results. The temporary material cost practically nothing, and the labor was the biggest part of the job. We had running water to contend with all the time, although it caused us no trouble except the inconvenience.

Mr. Teaford:—We had just about such an experience, except that we had no culvert to remove. It was a case of accumulation of water above the track that had to be let out. We tunneled through, using second-hand ties, just as Mr. Reid has outlined, and it worked very well. Of course, we would tunnel in a short distance, encase the opening, and then truck out the material with a light push car. It was rather slow, crude work, with but few men on the job at a time, but those that could work made fairly good headway, and by tunneling and encasing made an opening sufficiently large to put in the pipe. There was a distance of 35 or 40 ft. from the rail under a single track.

Mr. E. U. Smith:—I know of a case where a tunnel was put under the Pennsylvania railroad several years ago for a 24-in. sewer, using oak bents.

Mr. J. S. Robinson:—We had a case similar to the one cited by Mr. Reid, except that the structure that failed in our case was a double 48-in. cast iron pipe 180 ft. in length, under a 56-ft. embankment. We tunneled through the embankment, using old timber, in the manner described by Mr. Reid. No piles were driven. We then constructed a 6-ft. brick arch, 166 ft. long, backing it with concrete, asphalted it over the top, removed the timbering and packed blue clay thoroughly over the arch. The work was so well done that the embankment never settled. Where the depth is 20 to 40 ft. we tunnel and find it very successful and quite cheap. The cost was about $10 per lineal foot for tunneling and timbering and the same amount of labor and material for the arch, including waterproofing with asphalt and back-filling with clay over the arch as the timbering was removed. In replacing wooden boxes with cast iron or concrete pipes we always drive piles where the embankment is over 7 ft. high. Under 7 ft. we use stringers on mud sills.

Mr. Rear:—We have tunneled through some sand fills by the same method and find that it is slow work. We have to drive lagging ahead on top and both sides and the work is quite expensive. I do not know what the cost of this work amounted to, but no doubt it was more expensive than the figure given by Mr. Robinson.

Mr. Sampson:—In the fall of 1911 we had to protect a four-track road bed on the New Haven road to allow the city of Boston to build a waterway 24 ft. in diameter underneath. This was on a gravel bank perhaps 20 ft. high with the natural earth below

it with quicksand at the grade line, 42 ft. below the track. We decided to make an open cut and the first move was to drive piles, the plan being to use one pair of old deck girders under each of the four tracks. These old girders were on hand and varied in length from 65 to 80 ft. We drove groups of 10 piles under each track at each end of the girder spans and capped them with 12x 12 timbers. We began about 12 midnight, on Saturday, after the last train had gone, taking two tracks at a time. The piles were driven, and excavation made, taking two tracks to a depth sufficient to cut and cap the piles at proper grade to receive the girders. The pits were then filled in again and traffic resumed. On the following Sunday other excavations were made to the full depth and length required to put in a pair of girders. Having been previously assembled, the girders were lowered into position, in the same length of time, between midnight Saturday and five o'clock on the Sunday afternoon following. The work was accomplished so that trains always ran at full speed and there was no other interruption of traffic. A standard bridge floor was placed on top of the girders and they answered all purposes for fully a year or more. The city contractors afterward excavated through the railroad embankment to the depth of the natural soil, putting in timber sheeting and bracing, and have gone to a depth of perhaps about 20 ft., sufficient to give them clearance to operate a steam pile driving hammer. They drove steel sheeting in lengths of about 20 ft., so that they went about 3 or 4 ft. below the grade of the conduit. That sheeting braced apart by ordinary timber struts, was a sufficient support to allow the conduit to be built of full section. Afterwards the girders were buried and left there, because it was cheaper to sacrifice them than to pull them out. The western side of this embankment was held up by a granite rubble masonry retaining-wall and a highway immediately adjoining was 22 ft. below the track grade., The conduit passed below the bottom of the retaining wall. The work was accomplished without removing any part of the retaining wall, nor was it injured.

SUBJECT No. 10.

SNOW FENCES.

REPORT OF COMMITTEE.

Your committee prepared and caused to be sent to engineers of those railways which probably have had experience with snow, a circular letter asking for data regarding the practice and embodying the views of these men with reference to the subject of snow fences. The accompanying drawings show the different types of portable and stationary fences commonly used. For the benefit of those who by reason of geographical location do not have to contend with snow, it may be stated that the sole object of making and placing snow fences is to collect the snow in piles or drifts before it reaches the track where it would otherwise find lodgment in cuts and obstruct or prevent the movement of trains.

The opinions as to the merits of snow fences expressed in replies to our circular letter were not unanimous regarding their advantages. It is the belief of the committee that where conditions prevent the placing of fences in advantageous positions, no benefits and much harm may result from their use. To make this point clear the first essential to the use of snow fences is that there shall be sufficient space between the cut and the nearest string of fence (assuming that the worst places require more than one row) to prevent the drift formed by this fence from extending into the cut. Experience based upon personal observation during one severe winter will enable one to decide upon the proper location of the fence. It should, of course, be placed as nearly windward from the cut to be protected as possible. Because of the varying direction of the wind, this will not always be possible but the prevailing direction will govern. It is probably true that in most locations nearly all the bad storms come from one direction. A second string of fence should be placed parallel with the first and far enough away that its drift will not ordinarily lap over the first. Additional strings of fence as required can be located in the same manner. It is evident that if these parallel rows of fence cannot for any reason be placed far enough apart or far enough from the cut to prevent the drift from forming in the cut, harm rather than benefit will result. In this way, in agricultural communities where the railways own only a narrow right of way snow fences cannot be used advantageously.

At the higher elevations on the Union Pacific where the greater portion of the land has but little value for other than grazing purposes, the company has the privilege of locating its fences to secure the best results and it will frequently place four or five parallel rows of fence spaced 150 to 200 ft. apart where the land slopes downward towards the cut to be protected. On the other hand where the ground rises abruptly towards the cut it is necessary to place these strings 50 ft. or even a lesser distance apart.

Mr. R. Budd, chief engineer, of the Great Northern Railway, advises that tree planting is being done to a large extent in eastern Montana, North Dakota and Minnesota, and is proving a very effective means of protection against winds blowing across the track. The same effect is produced where sage brush or any other form of vegetation provides a lodgment for the snow.

On one branch of the Oregon Short Line owning a narrow right of way where, due to altitude, the seasons are short and the snowfall heavy with

considerable wind, the adjoining farmers oppose the accumulation of drifts beyond the natural snowfalls. Much trouble from snow results and other forms of protection must be employed by the railway.

With reference to the advisability of snow fences, Mr. T. C. Burpee, engineer of maintenance of the Intercolonial Railway advises: "I am not as favorable to the use of snow fences as some are for I believe that in a great many instances they create more trouble than they prevent, especially where they are placed within 50 ft. of the track, in which case they create a snow bank to the height of the snow fence after which the snow drifts on the track much higher than it would have done had there been no snow fence. To be of value, snow fences should be placed at least 100 ft. from the track. However, with the powerful locomotives and the snow fighting equipment which we have today, snow is not the same menace as it was years ago."

Mr. C. F. King, division engineer Chicago & Northwestern Ry.:—We build a special fence constructed by placing ordinary lath fencing on a framework which is attached to the ordinary barbed wire fence.

This is effective for catching drifting snow and sand. (A sketch of this fence is shown in the illustrations.)

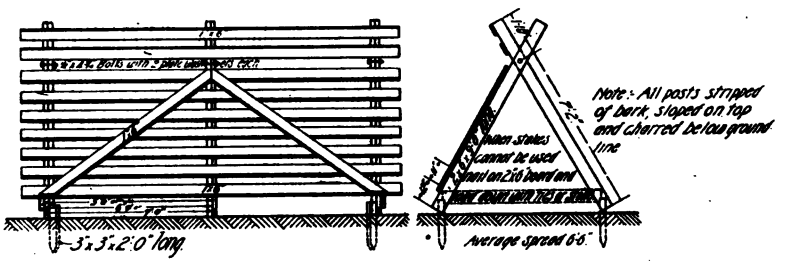
The Termoli-Campobasso line of the Italian State Railways is using snow fences made by combining pine planks with reinforced concrete standards. The standards, which are 10 ft. high above ground and spaced 6 ft. 7 in. apart, centers, consist each of a 4x5-in. reinforced concrete post leaning in a direction from the track, enlarged to 5x6 in. in section above a reinforced concrete vertical back brace 4½ in. in diameter and extending 6 ft. 3 in. above ground. The brace has a flaring base that is buried in broken stone ballast 3 ft. deep, and the leaning post and vertical brace are tied across by a reinforced strut just above the ground line. The leaning post foots against a concrete slab buried 2 ft. deep in ballast. The 1¼-in. planks fit into grooves in the leaning posts. (Engineering Review, Dec. 20, 1913.)

Mr. J. G. Gwyn, chief engineer of the Denver & Rio Grande, advises that, "the type of snow fence built depends upon the locality in which such fence is to be erected. On some portions of the line we have in the past built the customary horizontal board snow fence, while in others, especially in the more mountainous districts, we have constructed high snow fences of poles after the old style zig zag rail fence. We have not been maintaining snow fences recently as we are of the opinion that we are not justified in the cost of such maintenance. Of late years we have been in doubt as to the economic value of snow fences in the territory served by our line."

The committee believes that the nature of the country traversed by the Denver & Rio Grande makes the construction of snow fences very expensive and the mountainous character of much of this line makes the results very doubtful. We are of the opinion that a hilly, rolling or open country, generally free from vegetation, offers the greatest possibilities for the use of snow fences.

We recommend for general use a portable type of snow fence built of 1 in. by 6 in. by 16 ft. rough fencing lumber braced and nailed onto supports of 2 in. by 6 in. timbers. Such a fence stands about 7 ft. high and is built in 16 ft. panels. The bottoms of the supports are connected by a 2 in. by 6 in. by 8 ft. timber to brace them on the ground and to keep the supports spread. Hardwood stakes 3 in. by 3 in. in size or ⅞ in. round iron fastenings are used to anchor the fence to the ground and to prevent it from blowing over during high winds. Stone is also sometimes used when convenient. This fence is standard on the Oregon Short Line; the Chicago, Milwaukee & St. Paul; the Duluth & Iron Range and the Union Pacific. The legs of this fence swing on a bolt located three boards below the top and are held apart by a 2 in. by 6 in. timber bolted at the bottom. This fence folds up so that it occupies a vertical space of only 8 in. when lying upon the ground or when loaded upon cars.

In erecting the fence a form is constructed for nailing up the panels and four active men will set up a panel ready for loading on cars every four minutes. Where much fence of this type is to be erected, a work train is



To be placed not less than 100 Ft. from ℄ of Track.

BILL OF LUMBER - PORTABLE SNOW FENCE.

12'0" LONG.					14'0" LONG.					16'0" LONG.				
No.Pcs.	Size.	Length	Ft.B.M.	Purpose.	No.Pcs.	Size.	Length	Ft.B.M.	Purpose.	No.Pcs.	Size.	Length	Ft.B.M.	Purpose.
6	2x6	9'0"	54	Frames.	6	2x6	9'0"	54	Frames.	6	2x6	9'0"	54	Frames.
9	1x6	12'0"	54	Boards	9	1x6	14'0"	63	Boards	9	1x6	16'0"	72	Boards
2	1x6	8'0"	8	Braces	2	1x6	9'0"	9	Braces	2	1x6	10'0"	10	Braces.
4	3x3	2'0"	6	Plate Shoes	4	3x3	2'0"	6	Plate Shoes	4	3x3	2'0"	6	Plate Shoes
3	2x6	7'0"	21	Ties	3	2x6	7'0"	21	Ties	3	2x6	7'0"	21	Ties.

BILL OF HARDWARE.

3	½"x4¾" Black Bolts with Square Head and Nuts
6	½" Plate Washers
½	lb 2½" Cut Common Nails
½	3" " Clinch "
½	4" " Common "

Standard Portable Snow Fence, Canadian Pacific Ry.

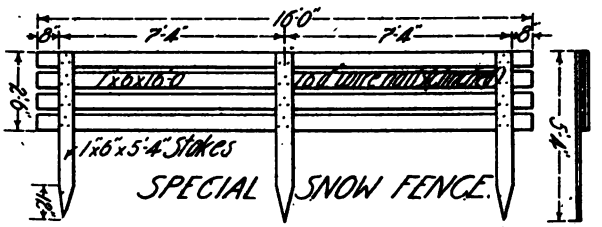
generally employed and the fence is unloaded from the cars as conveniently as possible. It is hauled from the car to its location on an ordinary lumber wagon fitted with a rack. Care should be taken to start the erecting of the fence early in the fall, say in September, so that work can be completed before bad weather comes and frost interferes with the driving of the stakes which hold the panels down.

The chairman of this committee has had much experience with snow fences during his service of over 20 years on the Union Pacific and has had no fences other than of the portable type in use. Howeyer, the committee does not wish to be understood as recommending the portable pattern because it can be moved during the winter storms as fence moved under those conditions will be damaged considerably. If necessary, we advise making and placing new fence after the original fences have become buried in the drifts. The economy of this practice will be evident when the fences are repaired the following season.

We find that it is customary to make a snow fence serve the purpose of a right of way or boundary fence in many instances. The conditions are exceptional where such a fence will provide the proper protection against

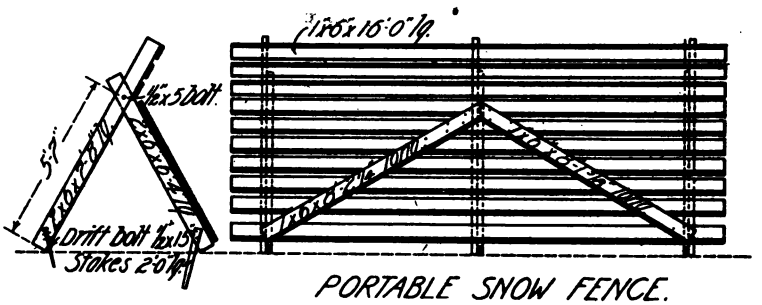
snow and we recommend a careful study of local conditions, including the direction of prevailing winds and the lay of the land before placing fences anywhere.

A. H. KING, *Chairman.*
F. E. KING,
C. F. KING,
FRANK LEE,
C. S. McCULLY,
Committee.



SPECIAL SNOW FENCE.

BILL OF MATERIAL FOR ONE PANEL.
4 boards 1"x6"x16'0" No. 2 fencing.
1 " 1"x6"x16'0" " " " for stakes
1 " 1"x6"x8'0" " " " for battens
¾ lb. 16d. common wire nails.



PORTABLE SNOW FENCE.

BILL OF MATERIAL EXC. OF STAKES AND D-BOLTS
Legs-3 pcs. 2"x6"x14'0" No. 1 com.
11 boards 1"x6"x16'0" No. 2 fencing.
3 carr. bolts ½"x5"
3 No. 10 punched washers for ½" bolt.
66-8 d. common wire nails
60-10 d. " " "

WHEN DRIFT BOLTS ARE USED.
6 drift bolts ½"x15"
12-3" wire staples.

WHEN STAKES ARE USED.
6 stakes from 2"x4"x2'0"
No. 1 com. ripped diagonally.
12-20 d. com. wire nails.

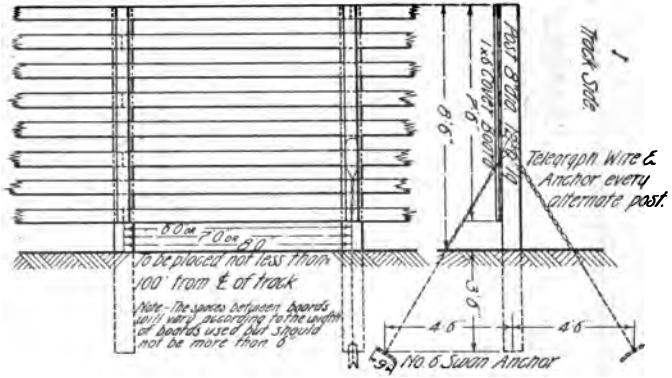
Standard Snow Fences, Chicago Milwaukee & St. Paul Ry.

BILL OF LUMBER-PERMANENT SNOW FENCE-OPEN BOARDING.

12'0" Panels					14'0" Panels.					16'0" Panels.				
No.Pcs	Size	Length	F.B.M.	Purpose	No.Pcs	Size	Length	F.B.M.	Purpose	No.Pcs	Size	Length	F.B.M.	Purpose
2	8dia	12'0		Posts	2	8dia	12'0		Posts	2	8dia	12'0		Posts
8	1"thick	12'0	60	Boards	8	1"thick	14'0	70	Boards	8	1"thick	16'0	80	Boards
2	1x6	7'6	7.5	Cover Bds	2	1x6	7'6	7.5	Cover Bds	2	1x6	7'6	7.5	Cover Bds

BILL OF HARDWARE.

1½	lbs. 3" Cut Common Nails.
30	lin. ft. No. 9 Galv. Iron Wire.
2	No. 6 Swan Anchors 3x9"


Post 8" Dia. 8'0" long
1"x6" Cover Board
8'0"
Track Side
Telegraph Wire & Anchor every alternate post.
6'0 or 7'0 or 8'0
To be placed not less than 100' from ℄ of track.
Note - The spaces between boards will vary according to the length of boards used but should not be more than 6"
3'6"
4'6"
4'6"
No 6 Swan Anchor

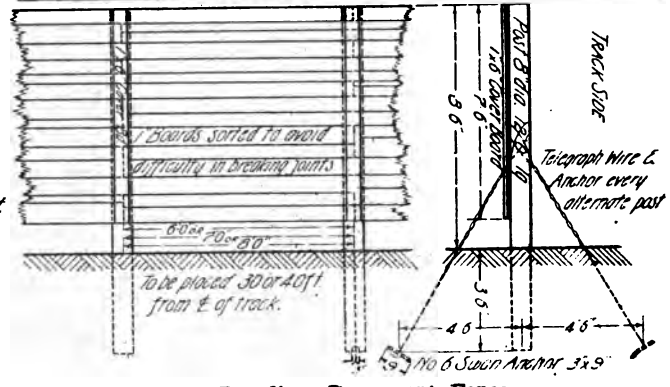
Open Boarding, Permanent Fence.

BILL OF LUMBER-PERMANENT SNOW FENCE-CLOSED BOARDING.

12'0" Panels					14'0" Panels.					16'0" Panels.				
No.Pcs	Size	Length	F.B.M.	Purpose	No.Pcs	Size	Length	F.B.M.	Purpose	No.Pcs	Size	Length	F.B.M.	Purpose
2	8dia	12'0		Posts	2	8dia	12'0		Posts	2	8dia	12'0		Posts
	1"thick	12'0	100	Boards		1"thick	14'0	120	Boards		1"thick	16'0	140	Boards
2	1x6	7'6	7.5	Cover Bds	2	1x6	7'6	7.5	Cover Bds	2	1x6	7'6	7.5	Cover Bds

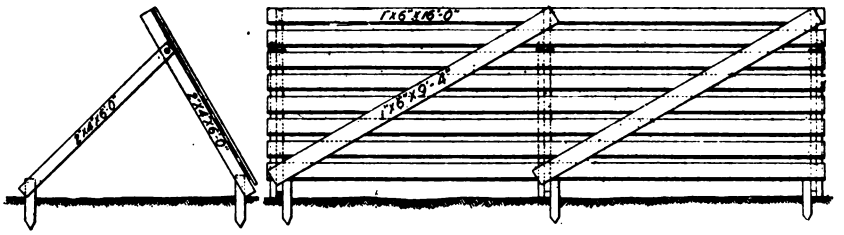
BILL OF HARDWARE.

3	lbs. 3" Cut Common Nails.
30	lin. ft. No. 9 Galv. Wire.
2	No. 6 Swan Anchors.


Post 8" Dia. 8'0" long
1"x6" Cover Board
Boards sorted to avoid difficulty in breaking joints
Track Side
3'6"
Telegraph Wire & Anchor every alternate post
6'0 or 7'0 or 8'0
To be placed 30 or 40 ft from ℄ of track.
3'6"
4'6"
4'6"
No 6 Swan Anchor 3x9"

Closed Boarding, Permanent Fence.

Standard Snow Fences, Canadian Pacific Ry.



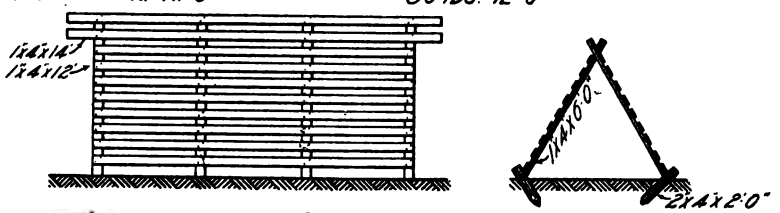
SECTION ELEVATION

BILL OF MATERIAL FOR ONE PANEL	
6	2"x4"x6'-0"
8	1"x6"x16'-0"
2	1"x6"x9'-4"
3	Carriage Bolts & Nuts ½"x4½ underhead
3	Plate Washers for ½" bolts
1-lb	10d Wire Nails (barbed)
¼ lb	8d Wire Nails (barbed)

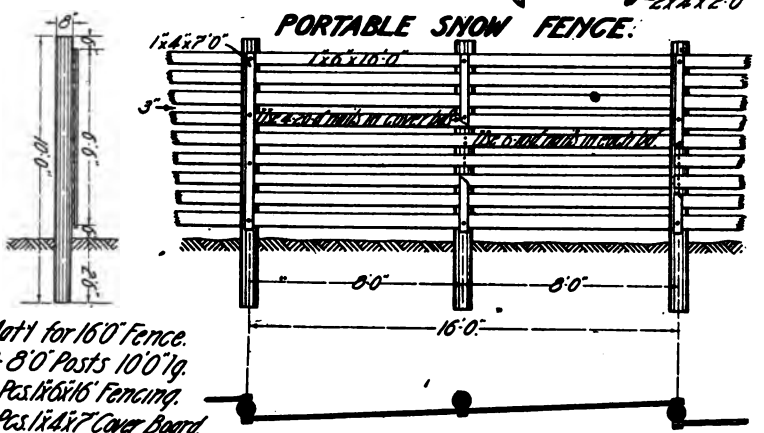
BILL OF MATERIAL FOR ONE MILE	
990	2"x4"x12'-0"
2640	1"x6"x16'-0"
660	1"x6"x9'-4"
990	Carriage Bolts & Nuts ½"x4½" underhead
990	Plate Washers for ½" bolts.
330 lbs	10d Wire Nails (barbed)
165 lbs	8d Wire Nails (barbed)

Material for one mile of fence.

4105 ft. B.M. 1"x4"x14'. 1773 ft. BM 2"x4"x2 (880 Pcs)
14080 " " 1"x4"x12'. 285 lbs. 8d wire nails
3520 " " 1"x4"x6' 30 lbs. 12d "



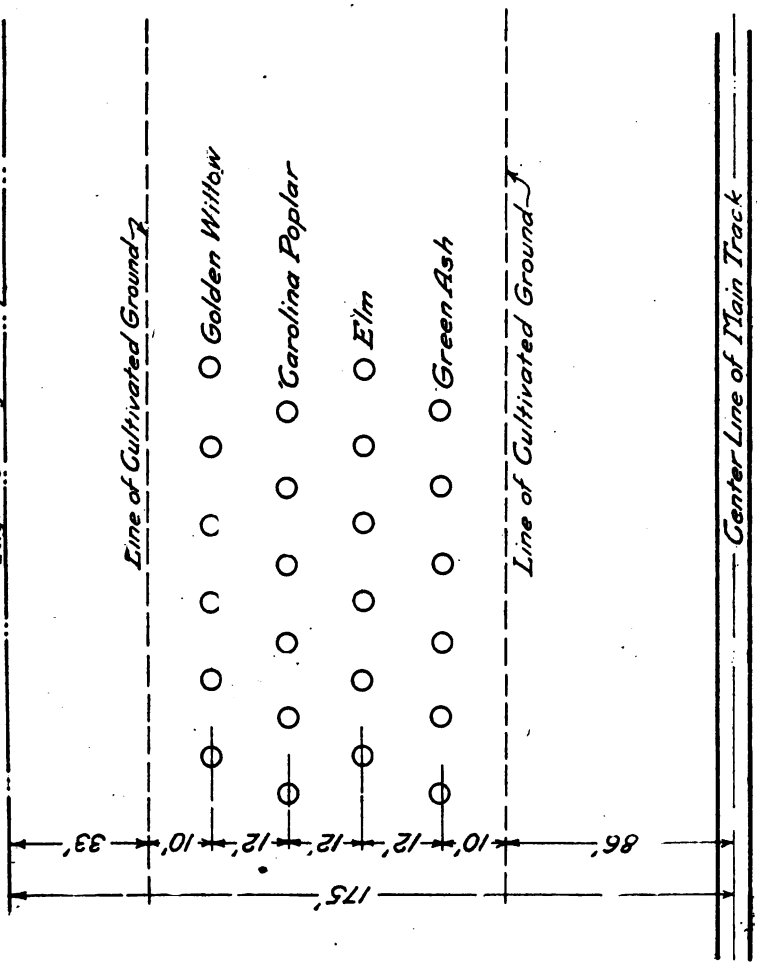
PORTABLE SNOW FENCE.



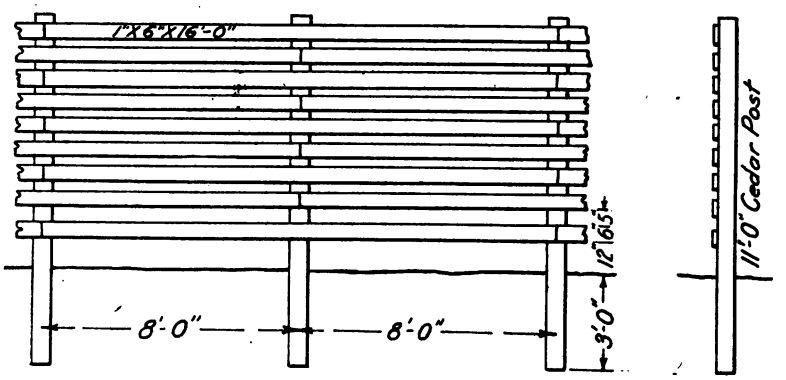
Mat'l for 16'0" Fence.
2-8'0" Posts 10'0" lg.
9 Pcs. 1"x6"x16' Fencing.
3 Pcs. 1"x4"x7' Cover Board.
75 lbs. 10d. Common Nails.
42 lbs. 20d

PERMANENT SNOW FENCE.

Standard Snow Fences, Great Northern Ry.

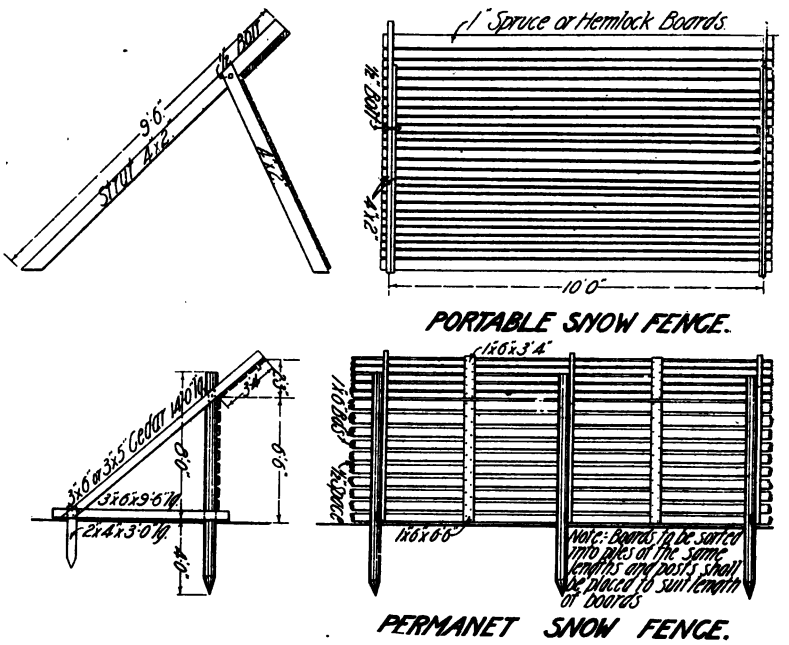


Standard Tree Planting for Protection against Drifting Snow, Great Northern Ry.

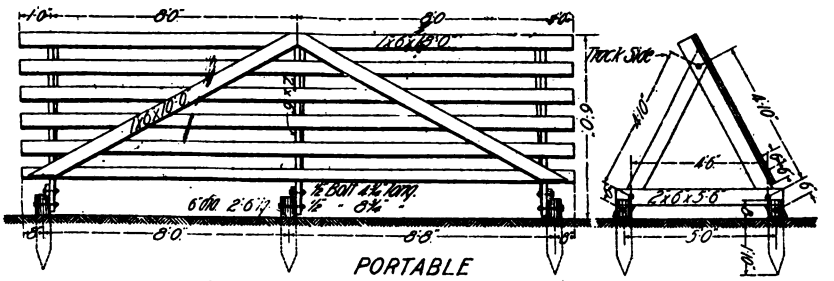


BILL OF MATERIAL FOR ONE MILE OF FENCE
661 Cedar Posts 11 feet long
2970 Pcs. 1"X6"X16'-0" - 23760 ft. B.M.
350 lbs. 10d Nails.

Special Snow Fence, Great Northern Ry.

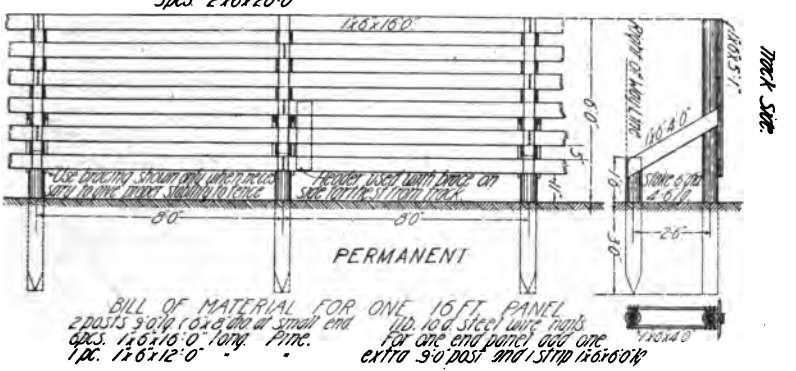

1" Spruce or Hemlock Boards
4 Rows
4"
10'0"
PORTABLE SNOW FENCE.
1x6x3'4"
1x6x6'6"
Note: Boards to be sorted into piles of the same lengths and posts shall be placed to suit length of boards
PERMANET SNOW FENCE.

Standard Snow Fences, Intercolonial Ry.



BILL OF MATERIAL FOR ONE 18 FT. PANEL

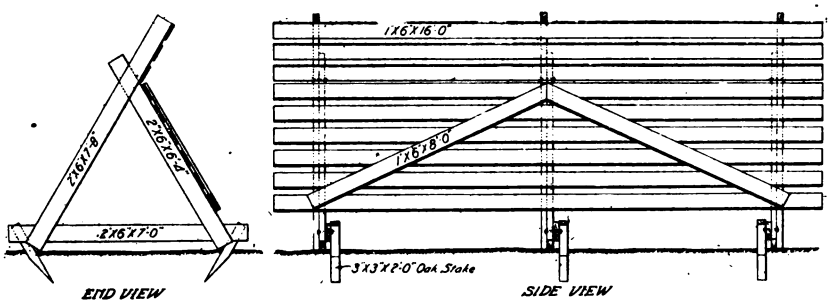
6 stakes 6" dia. 2'6" long.
6 pcs. 1"x6"x18'0" pine.
2 pcs. 1"x6"x10'0" "
3 pcs. 2"x6"x20'0" "
9 bolts ½"x4½" lg. with cut washers.
6 " ½"x8½" "
1 lb. 10d. nails.



BILL OF MATERIAL FOR ONE 16 FT. PANEL

2 posts 9'0" lg (6"x6" dia at small end
6 pcs. 1"x6"x16'0" long. Pine.
1 pc. 1"x6"x12'0" " "
1 lb. 10d steel wire nails.
For one end panel add one extra 9'0" post and 1 strip 1"x6"x60" lg.

Standard Snow Fences, Chicago, Rock Island & Pacific Ry.

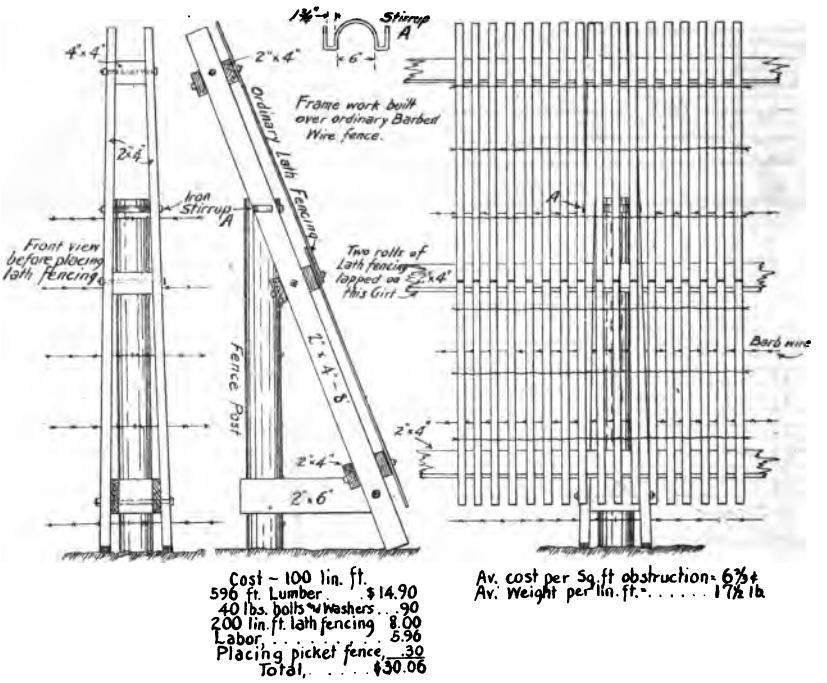


BILL OF MATERIAL FOR ONE PANEL

6 Pcs	3"x3"x2'0"	9' B.M.	Stakes Oak
3 "	2"x6"x14'0"	42 " "	Frame Pine
3 "	2"x6"x7'0"	21 " "	Frame ties "
2 "	1"x6"x8'0"	8 " "	Braces "
9 "	1"x6"x16'0"	72 " "	Boards "

9 Bolts ½"x5" (Carriage)
9 Plate Washers for ½" Bolts
½ lb 6d Clinch Nails
1 lb 10d Common Nails
½ lb 30d " "

Standard Snow Fence, Oregon Short Line Ry.


Stirrup A
4"x4"
2"x4"
6"
Frame work built over ordinary Barbed Wire fence.
2"x4"
Iron Stirrup A
Ordinary Lath Fencing
Front view before placing lath fencing
Two rolls of Lath fencing lapped on 2"x4" this Girt
A
Barb wire
Fence Post
2"x4"-8'
2"x4"
2"x6"
2"x4"
Cost - 100 lin. ft.
596 ft. Lumber . . . $14.90
40 lbs. bolts & Washers 90
200 lin. ft. lath fencing 8.00
Labor 5.96
Placing picket fence, .30
Total, ... $30.06
Av. cost per Sq. ft obstruction = 6⅔¢
Av. Weight per lin. ft. . . . . 1 ½ lb.

Special Fence for Snow and Sand, Chicago & Northwestern Ry.

DISCUSSION.

(Subject No. 10, Snow Fences.)

The Secretary:—In this report you will notice reference to tree planting, recommended and used by the Great Northern Ry., and claimed to be a very effective remedy. They use this method in the prairie country in northern Minnesota, North Dakota and Montana.

Mr. W. M. Clark:—I noticed as I came here that the Buffalo, Rochester & Pittsburgh apparently builds its snow fences permanently. In several cuts they have two fences, one about eight ft. high, built probably 100 to 150 ft. from the track, and the other about five or six feet high between the first one and the track. I presume these are very bad places and it was necessary to have the two fences. Through the Allegheny mountains there is a great deal of snow and it looks as though the fences there are

built permanently. The fence that we use is something similar to these shown in the report,—the panels being built at division headquarters. We take a form, place an iron plate on the top, lay the fencing material down and nail it through; the iron plate on the bottom side clinches the nails. The panel is then ready to take out on a work train and be set up by the section forces, with the assistance of one carpenter. We have some trouble with narrow right of way, but in general we have contracts with the land owners to pay them so much each year for the privilege of setting up fences on their lands. We are not allowed to set any before the middle of October, nor to leave them after the middle of March.

Mr. A. S. Markley:—I do not recall any information as to how the fences are stored during the summer. In a great many instances and in all cases where we rent land for snow fences we remove them early in the spring, before farm work begins. Our practice is to stack them in piles on the right of way and wire them together and place old ties on them to prevent the wind from blowing them upon the track. We lose some by being stolen or burned.

Mr. W. M. Clark:—We also pile them on the right of way. When it comes time to put them up we send out some lumber and have them repaired where necessary.

Mr. Alexander:—I come from a snow country, as you may know, up in Maine. On our road the track master and the section men do the fencing. We do not have anything to do with it, but I think I know which is the best fence for us. We have tried the portable fence with the inclined slope, shown in the report as being in sections, but they were not satisfactory; the snow would pile up and tip them over—more than with a straight fence. The most satisfactory fence with us is a straight, tight fence about eight feet high. We make a tight fence with the posts set in the ground and remaining there the entire year. Our right of way is about 100 ft. wide, so we can go out 50 ft. from the center of the track and place the fence where it is most needed. Sometimes we do not have room to get far enough away, but in most cases we do. I have seen fences 10 ft. high drift full so that it became necessary to build six feet more on top of the first fence in order to hold the snow. We could not get along without snow fences in our country.

The Secretary:—Mr. Clark spoke of a double line of fence

along one road. The report mentions some roads in the western part of the country as having several lines. I noticed recently several places on the Union Pacific, in Wyoming, where they have as many as 17 lines of temporary fence. They cover entire fields. The amount of fence required for a single cut is enormous. Such cases, of course, are unusual and occur only in localities where the snow-fall is great and where high winds prevail. These fences are of the temporary type, set slanting and have open spaces in the panels.

The C. & N. W. is troubled more or less with drifting sand in places in Wyoming. In such cases we use a light fence, made of lath and wire—as shown in one of the illustrations, with very good results.

Subject No. 11

PRESERVATION OF TIMBER

REPORT OF COMMITTEE.

This association had a standing committee on this subject for several years and the reports contained in the proceedings for 1904-5-6-7 and 1908, contain much valuable information. However, as the membership has increased greatly in the past five years, and as copies of these earlier reports are not available for the newer members, the committee has endeavored to present the subject in such a manner as to be of value to the newer members, and hopes that it will be of interest to the older members as well.

A few years ago when steel and concrete began to be so extensively used, it was thought that timber construction would soon be a thing of the past, and the subject of its cost and preservation would be of little interest to the bridge and building man. However, such has not proven to be the case and with the growing cost and scarcity of good material, the question of getting the maximum value out of it has assumed great importance. The subject will be handled mainly from the standpoint of the consumer, as this association is not in a position to enter into a discussion of the merits of the different methods of treating timber.

The information herein was largely taken from the U. S. Forestry Department Bulletins.

Grouping of Timbers.

The timbers of the United States which are adapted to structural work are as follows:

Longleaf Pine *(Pinus Palustris).*

Found in the southern states from North Carolina to Texas. Heavy, hard, very strong, tough, fine grain, even and straight. The standard eastern timber for all heavy construction, bridges, trestles, etc., for which it is preëminently fitted by its great length and stiffness. Material can be had in long pieces free from serious defects and has enduring qualities which add to its value. Largely used for ties throughout its range.

Shortleaf Pine *(Pinus Echinata):*

Same range as longleaf pine and usually occurs with it. Heavy, hard, moderately strong, not durable untreated. Used for same purposes as longleaf pine and not always distinguished from it. Should not be used where great strength or elasticity is required.

Loblolly Pine *(Pinus Taeda.)*

Same range as longleaf and shortleaf pine. The present cut is largely second growth. Strength and stiffness each 77 per cent of that of longleaf pine. Growth rapid and annular rings variable, but often very wide; proportion of sapwood large. Used in bridge and trestle work and for ties. Not durable untreated but one of the easiest woods in the United States to treat.

Cuban Pine *(Pinus Heterophylla).*

Alabama, Georgia, Louisiana and South Carolina; Cuba and Mexico. Not available in the same quantities as the other southern pines. Very heavy,

slightly heavier and stiffer than longleaf pine (102 per cent and 106 per cent respectively according to Sargent). Grain fine and straight, rapid growth, durable and easily treated. Will probably be important in the future as longleaf pine is exhausted. Easily replaces longleaf pine on the ground after fire or lumbering. Same uses as longleaf pine, and loblolly pine and not distinguished from them.

Pitch Pine *(Pinus Rigida).*

Eastern coast states, Maine to South Carolina, New York, Ohio, Pennsylvania, Kentucky, Tennessee. Medium light and soft, strength 62 per cent of that of longleaf pine; brittle. More durable than loblolly pine but less than longleaf pine. Used for bridge timbers, heavy construction work, and cross ties. Decays rapidly untreated and does not hold spikes well. Grows on soils too poor to support other timber.

White Pine *(Pinus Strobus).*

Originally over entire eastern half of United States except extreme south. Supply nearly exhausted and present cut is largely second growth. Light, soft, weak, easily worked; heartwood durable in contact with the soil. Formerly used for bridges. Useful where great strength is not required.

Norway Pine *(Pinus Resinosa).*

Michigan, Minnesota, Wisconsin and Canada. Light, weak, moderately soft; not durable in contact with the soil, untreated. Suggested for posts, poles and ties after being treated.

Western White Pine *(Pinus Monticola).*

California, Idaho, Montana, Oregon and Washington, principally Idaho. Light, weak, flexible; heartwood durable in contact with the soil. Same uses as white pine.

Western Yellow Pine *(Pinus Ponderosa).*

Entire western third of the United States, largest cut in California, Oregon and Montana. Light, not strong (breaking strength 63 per cent of that of longleaf pine according to Sargent); not durable untreated, but easily treated. Proportion of sapwood usually large. Used for all heavy construction work, poles and ties.

Jeffrey Pine *(Pinus Jeffreyi).*

California, at higher levels than western yellow pine. Same properties and uses as western yellow pine and not distinguished from it.

Lodgepole Pine *(Pinus Contorta).*

Sierra and Rocky mountains. Light, soft, not strong; not durable when used untreated, but easily treated. Used for ties, posts and poles. Likely to be heavily drawn upon in the future in the Rocky Mountain states.

Douglas Fir *(Pseudotsuga Taxifolia).*

Pacific Coast from British Columbia to central California; west slope of Cascades and Sierras; Rocky Mountains from British Columbia to Mexico. Most abundant and largest sizes in Oregon and Washington. Strong and hard; not very heavy. Fairly durable untreated, but much more so treated. More used for heavy construction work than any other American species. Available in large sizes. Used for bridge and trestle work, piling, poles and ties.

Western Hemlock *(Tsuga Heterophylla).*

Pacific Coast from southern Alaska to northern California, British Columbia, northern Idaho, northwestern Washington; best stands in coast region and Cascade mountains of Washington. Light, hard and tough; stronger than other American hemlocks. Well suited for all but the heaviest construction work. Prejudice against it unfounded; lately sold under its own name. Used in bridges and trestles and for poles, piling and ties. Untreated hemlock piles in one case only slightly attacked by teredo in four years where fir was badly eaten. (Bulletin 115, Forest Service, Mechanical Properties of Western Hemlock.)

Western Larch *(Larix Occidentalis).*

Southern British Columbia, northeastern Washington, northern Idaho, northwestern Montana. Heavy, hard, strong, close grained; durable in contact with the soil. Used for structural timber, poles and ties.

Relative strength ratios:

Douglas Fir,	100.0
Western Hemlock,	88.0
Western Larch,	81.7

(From average modulus of rupture.) (Bulletin 122, Forest Service, Mechanical Properties of Western Larch.)

Southern White Cedar *(Chamaecyparis Thyoides).*

Coast swamps, from New Jersey to Florida. Light, soft, comparatively weak; heart very durable. Used for culverts, piling, poles, posts and ties. Ties too weak for heavy traffic, but good on trolley roads, etc.

Northern White Cedar *(Thuja Occidentalis).*

Northern lake states. Same qualities and uses as southern white cedar.

Western Juniper *(Juniperus Occidentalis).*

Idaho, eastern Oregon, Cascades and Sierras to southern California. Soft. weak, durable. Gives good service for ties where traffic is not heavy. Supply not large and more valuable for pencils.

Western Red Cedar *(Thuja Plicata).*

Northern California, Oregon. Washington, Idaho, British Columbia and Alaska. Principal supply in Washington and Idaho. Light, soft, weak, brittle; durable in contact with the soil. Used for poles in which it is available in lengths up to 75 ft.

Bald Cypress *(Taxodium Distichum).*

Southern states from Maryland to Texas, Kentucky, Tennessee, Missouri. Usually found in swamps. Light, soft, weak; very durable. Used for poles, posts and ties.

Redwood *(Sequoia Sempervirens).*

Narrow strip along California coast from Oregon line to the Santa Cruz mountains. Light, soft, moderately strong, brittle; very durable in contact with the soil; slow burning and easily absorbs water. Used for culverts, in bridges and trestles where strength is not the chief essential; ties for light traffic. Not attacked by ants in tropical countries.

Chestnut *(Castanea Dentata).*

Eastern states and central southern states. Light, soft, weak; liable to check and warp in drying; easily split. Used for ties, poles and posts. Chestnut sprouts rapidly from the stump (coppice growth) and reaches pole size (30 ft.) in about 42 years or if grown from seed in 57 years. Average life of pole untreated 12 years; would last indefinitely if treated. Sapwood is thin and can be easily saturated with preservative after seasoning. Seasoning depends on time of year poles are cut; summer cut poles two months, spring three months, winter five months, and autumn seven months.

Red Gum *(Liquidambar Styraciflua).*

Lower Ohio and Mississippi valleys and south east coast. Hard, heavy, straight, close grained. Used for ties and found unsatisfactory on account of the difficulty in seasoning and their usually checking badly when spiked.

Tupelo Gum *(Cotton Gum)* Nyssa Aquatica.

Southern Coast, Virginia to northern Florida, Gulf states to Texas, Arkansas, Missouri, western Kentucky and Tennessee. Grows only in swamps and wet situations. Light, soft, weak, close grained, difficult to split. About same weight and strength as red gum, but much tougher. Same uses as red gum.

Black Gum *(Nyssa Sylvatica).*

Range about the same as tupelo gum. Wood heavy, soft, strong, tough; not durable. Used for piling.

Tamarack *(Larix Laricina).*

Northern lake states and northern Canada east of the Rocky mountains. Heavy, hard, very strong, durable. Used for posts, poles and ties.

Red Spruce *(Picea Rubens).*

White Spruce *(Picea Canadensis).*

New England and northern states. Light, soft, close grained, weak. Used for pulp and will only be of local importance for lumber (Sargent).

White Oak *(Quercus Alba.)*

Eastern United States and Canada. Most abundant in Ohio basin and Mississippi valley to the northern half of Arkansas and central Mississippi. Heavy, hard, strong and durable in contact with the soil. The standard tie timber of the eastern states and also used widely in construction, cooperage, finishing, flooring, etc. Liable to check in open air unless carefully seasoned. Forty-five per cent of the ties used in 1907 were reported as being white oak (including chestnut and post oak). Length of life of ties untreated 8 to 10 years.

Chestnut Oak *(Quercus Acuminata).*

Appalachians and Alleghanies from south central Pennsylvania southward to Tennessee and eastern North Carolina. Becoming more valuable because of use as substitute for white oak. Heavy, very hard, strong, close grained, durable. Formerly only used for tan bark. Grows on poor soils at high elevations. Used for ties and bridge timbers.

Red Oak *(Quercus Rubra).*

Same distribution as white oak but more abundant. Heavy, hard, strong; not durable as white oak. Same uses as white oak, including ties. Life of ties untreated 5 years; treated with zinc chloride (Burnettizing process) estimated 12 years; 20 years or longer if creosoted.

Beech *(Fagus Americana)*.

Eastern states and Canada, largest size in the basin of the Ohio river and slopes of the southern Alleghany mountains. Hard, strong, tough, close grained; not durable untreated; difficult to season. Used for ties, treated. Other species extensively used in France and Germany, creosoted, and length of life there reported as 18 to 30 years, or 10 to 12 years when burnettized.

Sugar Maple *(Acer Saccharum)*.

Northeastern United States and Canada. Most abundant in Minnesota, Wisconsin, Michigan, Maine and Appalachian slopes. Heavy, strong, dense and very hard. Not durable untreated. Used for ties, treated. Reported life, burnettized 15 years; creosoted, life estimated at 18 years.

LENGTH OF LIFE OF UNTREATED TIMBER.

The life of timber varies with the mechanical strain and wear it is subjected to, and with the factors which cause or prevent decay by the attacks of fungi. These factors are temperature, humidity, the proportion of sapwood, the amount of sap in the wood (depending on the season when cut and the treatment after cutting, e. g., whether watersoaked or not), and the time and conditions of seasoning before being placed in service.

Timber in a perpetually dry atmosphere or entirely submerged in water may last indefinitely and many examples of each are known. An example of the former is the statue of Cheops near one of the pyramids in Egypt with a life of upwards of 3,000 years. Examples of the latter are the houses of the lake dwellers in the Swiss lakes which were preserved under water from prehistoric times. All fungi require a certain temperature and a certain amount of moisture, air and food. The last may be the wood fibers or the albumen, sugar, etc. in the sap, or both. In case of timber naturally durable in the soil, such as redwood, cypress, cedar, etc., the sapwood is commonly destroyed in from three months to two years. The heartwood is protected by the antiseptic oil or other substances naturally occurring in the wood. In humid climates, as along the gulf coast, other timbers exposed to the weather decay very quickly unless treated.

The life of timber varies with climatic conditions and also with the properties of the soil; therefore no accurate length of life can be given which will apply to the country as a whole, but we believe it to average about as follows:

	Length of life (years)	
Variety	In contact with soil	In air
Cedar,	20	..
Chestnut,	12	..
Cypress,	20	20
White oak,	10 to 15	15
Long leaf pine,	10	12
Norway pine,	6	10
White pine,	7	10
Spruce,	7	10
Tamarack,	8	10
Douglas fir,	8	16

In some localities timber will not last as long as this, and in others it will last a great deal longer. In the interior valleys of California and parts of Arizona and New Mexico timber has a much greater life, especially when not in contact with the soil, trestle decks of Douglas Fir 25 years old being common, and some as old as 30 years having very little decay.

Long leaf pine and Douglas fir are the best varieties for structural work and have a fairly long life when not in contact with the soil; on the other hand, cedar, cypress and redwood have a fairly long life in contact with the

soil but are useless for beams, etc., as they are too weak and brittle. White oak perhaps is the best all around timber, being durable both in the air and when in contact with the soil, but there is not a sufficient supply to permit of its use for structural purposes and it has more value for other uses.

A great deal can be done to lengthen the life of untreated timber, viz.:—

1. By the selection of the proper varieties for the different parts of the structure—using the woods that are durable in contact with the soil for piles and footings, and the pines and firs for that part of the structure which requires strength but is not in contact with the soil.

2. By using concrete or masonry footings and keeping all timber away from the ground.

3. By keeping drift and other accumulations away from the timber (this applies to the stringers and caps as well as to the sills and posts).

4. By cutting the timber at the right season of the year and taking proper care of it during seasoning.

5. By protecting the structure from the weather.

Bridges have been kept in good condition for 50 years by housing them in, and other methods of protection have preserved timber for 25 to 30 years, but as very few wooden spans are built at present this method is not of as much interest as in the past. The great increase in the weight of equipment has probably been the cause of the removal of more protected spans than decay. It is doubtful if any practical method of protecting trestles from the weather has been found although some of the methods used for fire protection also protect the timber from decay.

It is important in bridge and trestle work that all parts of the structure should have the same life or that the life of one part should be a multiple of that of the other. For example, if the piles in a pile trestle are good for six years and the deck for eight years, a large percentage of the value of the deck is thrown away as it is seldom economical to put an old deck back on new piles when driven. Again, if the piles are good for 16 years and the deck for 12 years, a great deal of new material is put in the deck the last year or two, or the piles are renewed before giving all the service possible. Conditions are frequently found where either the piles or deck may be good for a few years more, but the other part is badly decayed and entire renewal is necessary. In pile trestles it is most important by far that the piles have the longest life as it is much easier to repair or replace any of the other members of the structure.

Piles decay almost invariably at or near the ground line, and many methods have been adopted to increase the life of the piles when they become badly decayed, some of which are:

1. Splice individual piles by cutting them off below the ground. This method is good where only one pile in a bent is decayed, but not more than one in a 4-pile bent or two in a 5-pile bent should be so repaired.

2. Cut off all piles in a bent below the ground and put on a framed bent. This is a good method and is probably the most practical one.

3. Either before or after a pile has become decayed incase it in concrete for about two feet below to two feet above the ground line. If the pile is decayed some vertical reinforcement is necessary and in any case it is advisable to place some wire netting around the pile. If properly done this method is probably the best and the trestle will not lose any of its stiffness. The cost will average about $5 per pile and it will then be good for several years. Of course the condition of other parts of the structure should be taken into account before applying this method to many piles as it would prob-

ably not pay to repair them in this manner unless the deck is good for three or four years.

What Decay Is.

The decay of wood is not an inorganic process, like the rusting of iron or the crumbling of stone, but is due to the activities of low forms of plant life called bacteria and fungi. Bacteria are among the simplest of all forms of life, often consisting of but a single cell, microscopic in size. Sometimes several such cells may be attached to each other, and so form a thread or filament. Usually they are colorless, and multiply by the division of the parent cell into other cells which, in turn, divide again.

Fungi, although much more complicated than bacteria, are also low in the scale of creation when compared with familiar flowering plants and shrubs. They consist merely of tiny threads or hyphæ, which are collectively known as the mycelium. In many of the higher forms of fungi the threads grow together to form compact masses of tissue. Familiar examples of these forms are the toadstools, which grow on damp, rotting logs, and the "punks," or "brackets," on the trunks of trees in the forest.

The causes of decay in wood, however, are not these fruiting bodies themselves. Spores, very primitive substitutes for seed, which are borne in the countless compartments into which the under surfaces of the fruiting bodies are sometimes divided, are produced in infinite number, and are so fine that they can be distinguished only by the microscope. When seen in bulk they appear as the finest dust. Like dust, they are carried by the wind and strike all portions of the surrounding objects. Few species of fungi successfully attack healthy living trees, and only a comparatively small number can attack and destroy wood. Yet the spores of some find a lodging in dead portions of a tree or in cut timber, and if the wood is moist and in the right condition for the spore to grow it germinates and sends out a thin, film-like white thread which, by repeated branching, penetrates the entire structure of the wood. These are the real agents of decay.

This is not the only way that a fungus can enter a sound stick of timber; for if a good stick is lying close to a rotting one, the mycelium may grow over or through the moist ground and so reach the sound stick, which it immediately attacks. Sometimes, too, when a tree is cut it already has a fungus growing in its wood. If the fungus happens to be a true parasite—that is, if it can grow only in living tissues—it will die when the tree is felled; but if it has been accustomed to growing in the heartwood of the tree, which is practically dead, it may continue to live and develop even after the tree has been sawed into lumber.

Wood is composed of minute cells. The chief material of the cell-walls is a substance called cellulose, and around this there are incrusted many different organic substances known collectively as lignin. Most of the wood-destroying fungi attack only the lignin; others attack the cellulose alone, while a third class destroy all parts of the wood structure. The lignin and the cellulose are dissolved by certain substances secreted in the fungi, and thus serve as food for the fungus growth. In this way the fungi can develop until they extend throughout every portion of the timber. After a time the amount of fiber changed into food and assimilated by the fungus causes the wood to become discolored. Discoloration may also be produced by pigments in the fungus or secreted by it. Finally so much of the wood fiber is eaten away or changed in composition that its strength is greatly diminished, the texture becomes brittle and disconnected, and the wood is said to be "rotten."

But food is not the only thing that a fungus requires for its growth and development. It must also have heat, air, and moisture. If any one of these is lacking the fungus can not develop. The necessary heat is supplied by almost every climate, and it is only in rare cases, as under water or deep under the surface of the ground, that air can be excluded from the timber. Of the four requirements, therefore, two are beyond control. It is only by depriving the fungi of food or moisture that the destruction they cause can be prevented.

How Decay Can Be Retarded.

By Seasoning.

The simplest way to prolong the life of timber exposed to the attack of wood-destroying fungi is to reduce the moisture content of the wood. The amount of water in green timber varies according to the part of the tree from which the wood is cut. The outer layers of the trunk are composed of sapwood, the cells of which contain large amounts of organic substances which serve excellently as food for the fungi. Moreover, sapwood always contains a large amount of water. It is the portion of the tree, therefore, most susceptible to attacks from fungi. Heartwood, which can usually be distinguished from sapwood by its darker or more reddish color, contains, on the other hand, much less moisture. It is therefore more durable than sapwood, but because its pores are stopped up by gums and resins it dries out much less rapidly than the more porous sapwood. In almost every case as much care should be taken thoroughly to dry out the heartwood as in the case of the moister sapwood.

By piling the timber so as to permit free access of air all around it the moisture content of timbers of certain sizes can be reduced to about 15 or 18 per cent. Of course the climate has a great influence on the rate at which the wood dries out and the total amount of moisture it loses.

The moisture content of air-dry wood can be still further reduced by kiln-drying; and this is employed to a considerate extent, but usually for other purposes than increasing the durability of the wood. Moreover, either air-dry or kiln-dry wood has the power to reabsorb moisture when exposed to the atmosphere in damp situations, and so the benefits of drying, as far as durability is concerned, are only moderate. Yet the increased life which it gives is, in nearly all cases, more than sufficient to repay the added cost of seasoning.

The strength of partially seasoned timber, other things being equal, increases as the amount of moisture it contains decreases. Thoroughly seasoned timber of small sizes is sometimes three or even four times as strong as the same timber, when green. Moreover, during the process of drying out, important but little understood changes take place in the organic contents of the wood cells, by which the wood is not only rendered less attractive to fungi, but is made more permeable and so better prepared for preservative treatment. All timber should be thoroughly seasoned before being exposed to decay.

An exterior coating secured by dipping a post in a thin solution of cement or other material that will harden on the post is not an effective protection, because in shrinking or swelling the wood forms cracks through which decay enters.

By Chemical Impregnation.

By far the best method of checking the growth of fungi, however, is to deprive them of food. This can be done by injecting poisonous substances into the timber, and so changing the organic matter from foods suitable for fungi into powerful fungicides. It is a mistake to suppose that the germs of decay are inherent in the wood, and only need an opportunity for development to bring about its destruction. Several processes for the preservation of wood have been founded on the false assumption that it is necessary to destroy the "germs" in the interior of the timber. The impression doubtless arose from the fact that, after a stick of timber begins to rot; it is impossible to tell just where the fungus spores germinated and gained entrance into the timber. Moreover, the fact that the interior of the wood may have reached an advanced stage of decay before there are any external evidences of the fungi —such as fruiting bodies, or films of mycelium—tends to convince the casual observer that decay starts from the interior. Yet the wood-destroying agencies start from the outside. This explains the efficacy of certain paints which merely form a superficial coating over the surface of the timber, but which

are poisonous enough to prevent the spores from germinating, or the hyphæ of most forms of wood-destroying fungi from penetrating into the unprotected wood in the interior. The ancients were in the habit of painting their statues with oily and bituminous preparations to preserve them from decay. The great wooden statue of Diana at Ephesus, which was supposed to have descended miraculously from heaven, was protected from earthly decay by oil of nard. Pettigrew extracted the preservative fluids from the heart of an Egyptian mummy that had resisted decay for over 3,000 years, and found that decomposition immediately set in. This showed that it was the presence of the antiseptics which prevented decay, and not a chemical change of the tissues.

Numerous processes for preserving timber have been patented, the principal ones being described in our proceedings for 1904 and 1908, but of these only four or five preservatives have been used to any considerable extent. Some of these preservatives are applied by several different methods, the most important of which will be described. The principal preservatives are creosote, zinc chloride, corrosive sublimate (bichloride of mercury), copper sulphate and possibly crude oil.

Creosote.

Creosote oil is a product distilled from coal tar which itself is a by-product obtained in the manufacture of illuminating gas from coal, or in the production of coke. The coal is heated in an iron retort from which air is excluded. The gas and tar are driven off and coke remains in the retort. The coal tar is distilled again and produces: oils lighter than water, oils heavier than water, and pitch. The pitch remains in the retort. The oils heavier than water constitute the commercial coal tar creosote. Creosote is a mixture of several complex substances of different boiling points. The chief of these are tar acids or phenols (including carbolic acid), naphthalene, a solid at ordinary temperatures (moth balls consist of naphthalene); anthracene, also solid at ordinary temperatures but when distilled from creosote usually in solution as anthracene oils, and a pitchy residue. All of these have antiseptic properties in different degrees. The tar acids are the strongest antiseptics but are also the most volatile and most easily dissolved in water. The naphthalene and anthracene oils are not so strongly antiseptic, but are less volatile and soluble. They are the constituents that are relied on to preserve timber treated with creosote.

Coal tar creosote is the standard antiseptic used to protect timber from decay and from destruction by white ants, marine borers and other enemies. It has been successfully used on a commercial scale since 1838, when the first patent covering the use of the dead oil of coal tar for treating timber was taken out in England by John Bethell. His process, known as the Bethell process, is still used. Although other substances have been tried as wood preservatives ever since then and hundreds of patents are taken out every year, coal tar creosote continues to be the leading material for timber preservation both in this country and in Europe and more timber is treated by the creosoting processes than by all others.

Creosote is sometimes adulterated with petroleum products, gas tar oil, wood tar oil and similar products. Most of these have no antiseptic properties or their effects on timber have not been proved. Therefore definite specifications are necessary to insure getting a pure coal tar creosote oil and a careful analysis of the oil should be made. Standard specifications for creosotes have been drawn up by the Forest Service, the American Railway Engineering Association and other associations.

The specifications for the American Railway Engineering Association are as follows:

The oil used shall be the best obtainable grade of coal tar creosote; that is, it must be a pure product of coal tar distillation and must be free from admixture of oils, other tars or substances foreign to pure coal tar; it must be completely liquid at 38 degrees Centigrade, and must be free from sus-

pended matter; the specific gravity of the oil at 38 degrees Centigrade must be at least 1.03. When distilled according to the standard method, that is, using an eight ounce retort, asbestos covered, with standard thermometer, bulb one-half inch above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below 200 degrees Centigrade, not more than five per cent below 210 degrees Centigrade, not more than 25 per cent below 235 degrees Centigrade, and the residue above 355 degrees Centigrade, if it exceeds five per cent in quantity, must be soft. The oil shall not contain more than three per cent water.

Zinc Chloride.

Zinc chloride is obtained by dissolving metallic zinc in hydrochloric acid. It is diluted by water before using for wood preservation. It is an excellent antiseptic and is easily applied by the pressure process described for creosoting, the only difference being that a dilute solution of zinc chloride is used instead of creosote. The following specifications govern its application to Douglas fir ties on the Southern Pacific, and practically the same method is used by other companies:

After the ties have been placed in the cylinders and the door closed, live steam shall be admitted at such a rate as to secure a pressure of 40 lbs. within two hours, as shown by a gage connected to the cylinder. This pressure should be maintained for periods ranging from three to six hours, depending upon the character of the timber and its condition.

A vent should be kept open in the bottom of the cylinder, or in the drain therefrom, to permit the escape of air and condensed water from the cylinder.

The length of time steam is to be kept up may be judged by observing the water escaping from the vent. When it becomes perfectly clear and contains no more sap, this is an indication that steaming may be discontinued. When this condition has been reached the steam should be blown off and a vacuum of 24 in. of mercury produced. This vacuum should be maintained for at least one-half hour, at the expiration of which time zinc chloride should be admitted without further breaking the vacuum and a pressure of 150 to 160 lbs. per sq. in. applied and maintained until the desired absorption is obtained.

The amount of solution injected shall be equivalent to one-quarter pound of dry soluble zinc chloride per cubic foot of timber. The timber shall contain from 2.5 to 2.7 per cent of zinc chloride; and under no circumstances shall it exceed 3 per cent. The solution shall be heated to a temperature of 160 to 170 deg. before it is admitted into the cylinders.

The zinc chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic, absolutely free from free acid, and containing not more than 25-1000 of 1 per cent of iron. The amount of chloride specified to be injected shall be of soluble zinc chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. The strength of the zinc chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc chloride according to the standard method made; the holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

We have not been able to locate any companies using copper sulphate for a preservative, and assume that its use has been practically abandoned. This process was known as Boucherizing.

Corrosive sublimate is the preservative used in the Kyanizing process. This process consists in steeping the timber in a dilute solution of corrosive sublimate in open tanks. It gives good results and is used quite extensively in the New England states for treating spruce.

KYANIZING.

Corrosive sublimate, or bi-chloride of mercury was successfully used by Homberg, a French savant in 1705, for preserving wood from insects. It was recommended by Dr. Boissieu in 1767. In 1730 the Dutch government tried it upon wood immersed in sea water as a remedy against the Teredo Navalis, but for this purpose it failed. In the Encyclopedia Britannica, in 1824, it is recorded that Sir Humphry Davy recommended its use for timber. Kyan's first patent, for the employment of corrosive sublimate for wood preserving, was taken out in 1832. His first success was gained by the preservation of the wood work of the Duke of Devonshire's conservatories. Kyanizing was for a long time by far the most popular of the timber preserving processes in this country, and the name is to this day frequently applied erroneously to other systems. Used in sea water, however, by the British Admiralty, this process proved a failure, as it had done under similar circumstances with the Dutch government a century earlier. Kyanizing has met with a considerable amount of success in comparatively dry situations; but in water and particularly in sea water, it appears to have invariably failed as have all the salts of metals. Corrosive sublimate is somewhat volatile at ordinary temperatures; it also has the drawback of producing injurious effects upon the workmen employed in handling it.

(Taken from "The Preservation of Timber by the use of Antiseptics," by Samuel Baxter Boulton.)

Crude oil, having an asphaltic base, is used to some extent as a preservative, but depends on its waterproofing rather than on its antiseptic qualities. It is applied by the full cell pressure process, described for creosoting.

The principal methods of applying creosote are: the full-cell pressure system, the empty-cell pressure system, the boiling system and the open tank or non-pressure system.

FULL CELL PROCESS.

The Bethell or full-cell pressure system is as follows: The timber is placed on iron trucks and run into a horizontal cylinder large enough to receive it and strong enough to withstand high pressure. Most cylinders have doors at each end, although some open at one end only. These doors, when closed are bolted up on a gasket making a tight joint. Cylinders as large as 9 ft. in diameter and 150 ft. long are in use. After the doors are closed live steam is admitted into the cylinder and a pressure up to about 20 lbs. is maintained for several hours—(a higher pressure is liable to injure the timber). The steam is then blown out and a vacuum created, which exhausts as much of the moisture from the wood as possible. The cylinder is then filled with creosote and pressure applied until the desired amount of creosote is injected into the wood. The pressure is then released and the doors opened and the treated timber withdrawn.

EMPTY CELL PROCESS.

The empty-cell treatment is given by two processes, known as the Rüping and Lowry methods. The idea is to give a deep penetration with a small amount of creosote, using only enough oil to paint the walls of the wood cells, leaving the cells empty. This treatment is much cheaper than the full-cell treatment and is largely used for treating cross ties.

The Rüping process is one of the best-known "empty-cell" processes, and has been used largely in both Europe and America, but only with creosote. The preliminary processes of steaming and vacuum, as carried out in the Bethell treatment, are omitted entirely, and the wood is allowed to become air-dry before it is put into the treating cylinder. As soon as the doors are closed air is forced into the cylinder at a pressure of about 75

pounds, and so held until the spaces in the interior of the structure of the wood are filled with compressed air. Then, still maintaining this pressure, the oil is forced into the treating cylinder at a somewhat stronger pressure—say 80 to 85 pounds—and after the timber is all covered by the preservative the pressure is increased to about 225 pounds. This forces the oil to penetrate into the interior of the timber. Finally, the valves are opened, and the surplus oil is run back into the receiving tanks. This, of course, relieves the pressure around the timber, and the expansive force of the compressed air in the interior of the wood, sometimes strengthened by a vacuum drawn in the treating cylinder, forces out much of the oil, leaving merely a coating around the cell walls. A comparatively deep penetration, with a light absorption, is thus secured.

Like the Rüping method, the Lowry process aims to secure a good penetration with a comparatively small quantity of preservative. Also in the Rüping, the timber is air-dried before treatment, but no compressed air is employed. During the seasoning process the evaporated water is replaced by air, and as soon as the cylinder doors are closed the oil is admitted and forced into the timber by pressure. This causes a compression of the air in the wood cells and intercellular spaces. Finally, the oil is run out of the cylinder and a strong, quick vacuum is drawn, and, as in the Rüping process, the sudden expansion of the air in the interior of the wood drives out the superfluous oil.

Boiling Process.

Douglas fir is a very hard timber to treat and it is almost impossible to treat it when seasoned. The boiling process was developed by Mr. John D. Isaacs and the late W. G. Curtis, for the treatment of green timber, the artificial seasoning by boiling in oil being very much less liable to weaken the timber than the steaming process. The specifications for this process are as follows:

The piling and lumber are to be placed on iron trucks, bound with iron chains, run into the treating cylinder, the doors closed, and hot creosote (about 160 deg. F.) pumped into the retorts until the load is covered, but leaving a space of 10 in. from the top of the oil to the top of the retort. Steam shall then be admitted through the steam heating coils into the cylinder, raising the temperature of the oil therein as fast as practicable to the boiling point of water (212 deg. F.). The vent pipe from the treating cylinder is to be kept open to the condenser and cold water kept circulating through the latter. Steam must be regulated through the heating coils so that the temperature will keep gradually rising as fast as the condensation will admit, until near 220 deg. F., when it will be found necessary to reduce the amount of steam, so that a constant and regular temperature can be maintained, with 220 deg. as a minimum and 225 deg. as a maximum. This constant and regular temperature must be maintained until such time as the amount of condensation collecting in the hot well of the condenser shall be reduced so as to be making not more than one-eighth pound of water per cubic foot of timber per hour.

The treating cylinder shall then be filled with hot creosote oil having a temperature of 180 deg. F. as nearly as possible until a pressure of five pounds is obtained on the pressure gage. The pressure shall then be started, drawing oil from the measuring tank and forcing it into the timber until such time as it shall have absorbed ten pounds per cubic foot. This amount shall be retained in the material after draining in the treating cylinder. On this being accomplished the charge may be removed when the temperature in the treating cylinder is reduced to 200 deg. F., but not until then.

In treating dry seasoned sawn timber it is advisable not to exceed 212 to 214 deg., and the pressure used in injecting the oil should be as low as possible, not exceeding 120 lbs. per square inch. The piles upon coming from the treating cylinder shall be free from all heat checks, water bursts or any other defects due to inferior treatment, and when bored midway between the ends shall show absolutely no moisture in the center. Borings beyond the

penetration of the creosote oil shall have their natural elasticity and strength.

Material is inspected by boring with a one-half inch bit and the depth of black oil observed which for a 10 lb. treatment is from three-quarters inch to one inch. The hole is then plugged with a creosoted plug made to a driving fit.

Open Tank System.

The open tank method has largely been developed by the United States Forestry Department and is described as follows:

A suitable open tank with some means of heating the oil, is provided. The oil is heated to about 200 deg. F. and the timber placed in it for four to six hours. The oil is then allowed to cool or, better, the timber is transferred to a tank of cold oil for a few hours. As the timber cools and the expanded air in the cells contracts, the oil is drawn in, giving a good penetration in many varieties of timber. Creosote, carbolineum and many other preservatives are applied in this way and the method is particularly adapted to the treatment of poles and posts, which are only given a butt treatment.

The Boucherie Process.

This process differs from all others in its method of application. It consists in injecting a salt solution into the newly felled trees by hydrostatic pressure, hence it can only be used on timber intended for poles, posts, mine props, etc. The apparatus required is very simple, consisting of a tank at a sufficient elevation to give enough pressure to force the solution through the poles, which height varies with the kind of timber, amount of moisture in the timber, etc., also piping to carry the solution, caps of cedar or some other nonporous wood to fit over the butts of the poles and a trough at the lower end to catch the solution. The butt end of the pole is elevated six inches to a foot and a half above the top. The solution must be applied to green timber within a few days after cutting. The sapwood is filled by the solution which drips out at the lower end. French officials claim 18 years for average life of poles treated by this method, and German officials 11.7 years. There is little gain for timber to be set in wet locations in soils containing lime or in sandy soils.

The Forest Service experimented with this method in 1912 at North Bloomfield, California. The results were fairly satisfactory except with "Aczol" (see under preservatives), which deposited a precipitate that clogged up the lower end and stopped the flow. It also had a tendency to corrode the metal fittings.

Zinc chloride is soluble in water and soon leaches out of the timber, except in the very dry parts of the country. To prevent this leaching, a process known as the Wellhouse method has been developed, which is based on the tendency of glue and tannin to form a waterproof substance. A one-half per cent solution of glue is mixed with zinc chloride and injected into the timber, after which a tannin solution is separately applied.

Two methods have been developed to combine zinc chloride with creosote. In the Allardyce method zinc chloride is given as a first treatment followed with a light treatment of creosote. In the Card process the zinc chloride is mixed with the creosote and they are injected at one treatment. The mixture has to be constantly agitated to keep it mixed and this is done by the use of a centrifugal pump taking the mixture from the top of the cylinder and forcing it in at the bottom. Usually 20 per cent of creosote is mixed with 80 per cent of a solution of zinc chloride and the method of application is the same as when either solution is used alone.

For treating paving blocks, the creo-resinate process has been developed. This consists in impregnating the timber with a mixture of creosote and resin, the proportions varying from half and half to three-quarters creosote and one-quarter resin.

The Powell process consists in boiling green wood in a solution of sugar in an open tank. An antiseptic is added, the nature of which depends on the use for which the wood is intended. The process is claimed to afford protection against white ants, dry rot and other decay and to render the timber less inflammable.

"Aczol" is a preservative invented by Jean Gerlache of Belgium. It is a water solution of copper sulphate, zinc chloride and ammonia. The originator claims that this solution enters into combination with the wood fiber and thus becomes insoluble. Wood thus treated is claimed to be proof against decay, etc., and also against marine borers. The wood is treated by immersion in an open concrete tank.

"Locustine" is a non-volatile petroleum product combined chemically with certain animal and marine oils and powerful antiseptics. It is manufactured by the Stokes Wood Preserving Co., Philadelphia, and is used both as a brush application and in open tanks.

"Microsol" is a 70 per cent copper sulphate solution mixed with sodium sulphate, calcium sulphate, silica and a copper salt of a sulfophenol. It is used in 2 per cent solution in open tank or 4 per cent solution for brush treatment. An example claimed for it is that of wood "sound seven years in a damp moldy mine." "Cheap, odorless, non-volatile, colorless."

The Bruning-Marmetschke process, commonly known as the "B. M." process, consists of injecting into timber approximately a 3 per cent solution of zinc chloride and 1.5 per cent solution of aluminum sulphate. It is claimed that the aluminum sulphate dissolves the basic chlorides in the zinc chloride solution and carries them into the wood in solution and also combines with some of the substances in the wood forming insoluble compounds and thus preventing the zinc chloride from leaching out of the timber.

Structural Advantages of Preserving Timber.

In many localities, the native woods would be suitable for piles and many other uses, if they were durable enough to make it pay to use them. The cost of this material treated is often less than that of more durable material brought from a distance and in all probability it will give longer service. Sound sap-wood is as strong as heart-wood but very much less durable and, unless the timber is treated, it should be excluded as far as possible in structures exposed to the weather. As sap-wood takes the treatment better than heart-wood, this is an advantage instead of a defect.

Treating the timber permits the use of smaller sizes for piles, poles, etc., as no allowance has to be made for decrease of size when sap-wood decays. Timber containing sap-wood is also cheaper, as there is less waste in cutting it from the tree. For railroad structures, such as bridges, trestles, docks, coal bunkers, etc., there is no doubt but that creosote is the best preservative in use at present.

The committee will not make any recommendation as to the process to be used, but advises that the treatment be such as to give the following results:

For piles and other parts of a structure, that come in contact with the soil, a full cell treatment should be given, injecting all the oil the timber will take. This is especially necessary in piles, on account of their liability to shatter or check in driving. For timber not in contact with the ground a cheaper treatment may be advisable, but as deep a penetration as possible should be obtained, regardless of the quantity of creosote left in the timber.

The cost of creosoting varies in different parts of the country and depends somewhat on whether the railroad does its own creosoting or not. It also depends on the amount of creosote injected, but for purposes of comparison of cost it can be assumed to be 20 cts. per lineal ft. for piles and $20 per thousand feet B. M.

Table I has been prepared to show the annual cost of structures having a life of from five to thirty years and costing 10 to 60 cts. or dollars per

unit, as shown by the following examples: For instance, piles in a structure costing $0.30 per ft. in place and lasting 10 yrs., cost $0.0388 per year; if they last 16 yrs., they cost $0.0277 per year. Now if they cost $0.50 per ft. in place, they will have to last 22 yrs. to equal in cost those lasting 10 yrs. at a cost of 30 cts. and more than 30 yrs. to equal those lasting 16 yrs.

If framed timber costs $30 per thousand feet B. M. in place and lasts 8 yrs., it costs $4.64 per year, and it will have to last 16 yrs. at a cost of $50 per M, to result in the same cost per year.

It will be seen from this table, that considerable extra life must be obtained from creosoted timber to make it economical to treat it, and it is doubtful if it is economical to creosote those timbers which are durable without treatment. Other methods of treatment are economical and they will be

TABLE 1

Annual Cost of Structures Having a Life of from Five to Thirty Years and a First Cost of from 10 to 30 Units (Either Dollars or Cents)

FIRST COST	YEARS																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	25	30
10	2.31	1.97	1.73	1.55	1.41	1.29	1.20	1.13	1.06	0.99	0.96	0.92	0.89	0.85	0.83	0.80	0.71	0.65
20	4.62	3.94	3.46	3.09	2.81	2.59	2.41	2.26	2.13	1.97	1.92	0.84	1.77	1.71	1.65	1.60	1.42	1.30
30	6.93	5.91	5.18	4.64	4.22	3.88	3.61	3.38	3.19	2.96	2.88	2.77	2.66	2.57	2.48	2.41	2.13	1.95
40	9.24	7.88	6.91	6.19	5.63	5.18	4.81	4.55	4.26	3.95	3.84	3.69	3.55	3.42	3.31	3.21	2.84	2.60
50	11.55	9.85	8.64	7.74	7.04	6.47	6.02	5.94	5.32	4.94	4.81	4.61	4.44	4.28	4.14	4.01	3.55	3.25
60	13.85	11.82	10.37	9.28	8.44	7.76	7.22	6.77	6.38	5.92	5.77	5.53	5.32	5.13	4.96	4.81	4.25	3.90

dealt with later. It is not possible to show all the advantages of treated timber in dollars and cents, as the annoyance and inconvenience of tearing up and rebuilding structures under traffic are hard to calculate, but are nevertheless real.

Life of Treated Timber.

The next question that presents itself is how long can we expect creosoted material to last. It has been impossible to get figures from many railroads, so we will give the experience of the Southern Pacific only.

The Southern Pacific has in place, in trestles, about 105,000 creosoted Douglas fir piles, treated by the boiling process ranging in age from one to 23 years with probably more than two-thirds of them over 12 years old. Of this great number not more than 500 have ever been replaced on account of decay and many of these piles 20 or more years old are as good as when driven. There is no doubt but these piles will be good for 30 yrs. at least. The same timber would not have lasted eight years untreated. The number of decayed piles shown above is estimated and is considered to be above, rather than below, the actual number.

If these piles were all 40 ft. long let us see if it paid to use them.

An untreated pile costs

40 ft. pile @ 10 cts.,	$ 4.00
To drive, $6.00,	6.00
	$10.00

If it lasts 8 yrs., cost per year = $1.55.

A creosoted pile costs,

40 ft. @ 30 cts.,	$12.00
To drive, $6.00,	6.00
	$18.00

If it lasts 30 years, cost per year, ...$ 1.17
Cost untreated for 30 years, ... 46.50
Cost treated for 30 years, ... 35.10

105,000 piles @ $46.50 (untreated) $4,882,500
105,000 piles @ $35.10 (treated) 3,685,500

Saving $1,177,000
or nearly $40,000 per year.

This same company has in service quite a number of untreated cedar piles that are 20 years old and are still sound. These piles cost about 15 cts. per ft. and the driving costs about the same, making the total cost 30 cts. per ft. If they are good for 25 yrs. they will cost 2.13 cents per year and if good for 30 yrs., 1.95 cts. per ft. per year. Creosoted, they would cost 50 cts. per ft. driven and would have to last about 45 to 60 yrs. to equal the cost of the cedar untreated.

Redwood piles are also very durable but they are no longer cheap. All redwood piles are cut from large trees and take the price of square timber.

The average price for trestle decks in place is about $40 per M. if untreated, and $60 if creosoted. If the creosoted deck lasts 30 yrs. it will pay to creosote the decks in any locality where climatic conditions are such that the deck will not last over 14 yrs. untreated.

While it may not pay to give a pressure treatment to timber having a long life naturally it may pay to give it some other kind of treatment. It is a fact that, although cedar and other durable piles have a long life, they decay in some parts more than in others. In some instances, decay starts at the head or top and in other cases at or near the ground line.

A good brush treatment of creosote can be given for three or four feet at the ground and the head thoroughly saturated for 30 to 40 cts. per pile. If the pile is of any great length this will represent a very small proportion of its cost, or only about the same as one foot of pile. This treatment may increase the life of the pile several years and one year's extra life would pay. Creosote applied in this manner should be used hot, at a temperature of about 180 to 200 deg. F.

A large number of preservatives are sold under trade names, such as Avenarius Carbolineum, S. P. F. Carbolineum, Spiritine, Creolin, Imperial Wood Preserver and Cabot's Conservo Wood Preserver. The committee will not say anything in regard to the relative merits of these, as we have not been able to get any testimony either for or against some of them. However, very favorable reports have been received from users of Carbolineum. These preservatives cost a great deal more than creosote. They are said to have greater penetrating powers and are probably the best to use for brush treatment. When treated by the open tank method, it is probable that creosote is as good as any of the more expensive preservatives. The difference in cost is not so great when bought in small quantities, as the retail price of creosote will probably average 25 cts. per gallon as against 60 cts. to $1.00 for the brands mentioned above. Railroads and creosoting companies pay from 7 to 10 cts. per gallon for creosote depending on the amount of freight paid, etc.

Paints and Whitewashes.

Paints and whitewashes are often used as preservatives and are of great value as such, but they depend entirely on their waterproofing qualities for their efficiency. They are liable to crack and peel off and, if applied to unseasoned timber, cause dry rot. For this reason, timber should not be painted until it is thoroughly dry and seasoned. As a rule timber structures should not be painted for a year after erection. It is doubtful if very large sizes of timber should ever be painted on all four sides.

Mineral oil also depends on its waterproofing qualities for its effciency as a preserver, but has none of the faults of paint as it will not crack or peel

off. It does not close the pores and consequently does not cause dry rot. It may add to the fire hazard, but those oils that have an asphalt base do not add greatly to the risk.

Framing.

Whenever possible all framing of timber should be done before treatment even to the boring of holes, but it is very seldom that this can be done On a trestle the only framing absolutely necessary is to cut the piles to the right height and apply the braces. Stringers, ties, etc., can be framed and treated before going to the job, but this requires a refinement of workmanship not easily attained in this generation.

Truss bridges can be framed and treated without actual assembling, but very few wooden trusses are now built and in any case it is probably cheaper to house them in. As some framing is necessary it is important to do as little framing as possible and properly treat such framing as has to be done. When piles are cut off, the heads should be thoroughly saturated with hot creosote, after which a good coat of hot asphaltum or tar should be applied. If the cap does not entirely cover the piles, the heads should be chamfered on the sides, so the water will run off quickly and not work under the cap. Vertical bolt holes should be filled with hot creosote before bolting and those in caps should be bored before treatment.

Braces should be fitted to the piles and in no case should the skin of the pile be cut. Piles should be selected so all in one bent would be of approximately the same size and any large protrusions on the piles should be cut off before treatment.

No satisfactory method of treating horizontal bolt holes has been developed. It is not practical to fill the holes with creosote. It may be said that twenty years' experience with such work has not shown the necessity of treating them in any way, but where the piles are in water that varies in height, some treatment may be necessary. Experiments might be made by boring the holes a trifle small and burning them to size as the charring of the wood might help. However, if the bolts are kept tight there will be little trouble. In such cases it would probably be best to spike the braces on with boat spikes.

In most cases it does not pay to creosote braces and girts as they have a reasonably long life and are easily replaced. There is also a considerable amount of framing to be done on them and this would to some extent impair the value of the creosote. A good brush treatment with creosote after framing or, better, a good soaking in a tank of hot creosote is probably as good as a pressure treatment for girts and braces if they are of the usual small sizes.

There seems to be considerable difference of opinion among bridgemen as to the desirability of using cedar and cypress piles. Some claim that these soft woods are unsuitable on account of not standing hard driving, while others say they are satisfactory. The committee is of the opinion that, as a general rule, piles of these woods can be driven without injury to a sufficient depth to insure against settlement and that they will stand all the driving that a pile should be given in the usual class of structure. In some cases where a certain depth has to be obtained to prevent a washout or to get them low enough to prevent their being dug out in excavating, it may be necessary to use a harder pile.

As a rule, we would recommend the use of piles of cedar or cypress, untreated or with a brush coat at the ground line, wherever they can be obtained at a price of about 60 per cent that of creosoted material. We would recommend creosoted piles of the cheapest available material for all structures that are expected to be in use ten or more years, where cedar, cypress or white oak cannot be obtained at a favorable price. We do not recommend the use of creosoted material for caps, braces, stringers and ties of open deck trestles, but do recommend it for all parts of ballasted deck trestles. The above rec-

ommendations are to be considered as general and are not intended to apply to localities where untreated material has a very short life.

Where framed bents are used on a pile foundation, the piles should be cut off high enough to keep the sill of the bent clear of the ground (the higher the better). The question of preserving the material will depend on the cost of material and its economy in yearly cost, giving the preference to preserved material on account of the lessened delays to traffic due to reconstruction.

Marine Borers.

Along the sea coasts the timber in marine structures is subject to the attacks of wood borers, commonly known as shipworms and wood lice. The worms are either Xylotrya or Teredos, these mollusks being very much alike in structure and mode of life. The Xylotrya are the more abundant in the waters of the United States and thrive best in the warmer waters, although they are found all along the coast. They are not active near the mouths of large rivers where the amount of salt is influenced by the inflow of fresh water.

Fig. 1.—Typical Example of Work of Marine Borers.

The Xylotrya, when very young, attack the exposed surface of the wood and begin to bore, entering the wood through very small holes, which they continue to enlarge to accommodate their rapidly growing bodies. They secrete a calcareous substance which forms a hard lining around the holes. These worms do not derive any food from the wood, although the borings pass through their bodies. They attack the timber from the mudline to mean tide, although they seldom work below 30 feet. They always enter timber above the mudline, but once inside they often bore below it. They bore generally lengthwise of the timber but follow an irregular course. They grow to a length of six feet with a diameter of over an inch in tropical waters, but in our waters are usually about a quarter of an inch in diameter and up to five inches long. They will bore in any kind of wood but do not make as good progress in the harder and denser woods as they do in the softer kinds. Untreated pine and fir piles have been destroyed in one month and it is seldom they will last over three years in waters that are not affected by fresh water from rivers.

The Limnoria, or wood louse, is a crustacean about the size of a grain of rice, and, unlike the Xylotrya, it derives food from the wood. It attacks the timber from the outside and bores thousands of small holes, about one-eighth inch in diameter, so close together that the partitions between the holes are very thin and are soon worn away by wave action. The timber thus gets smaller and smaller until it is finally cut off. Where the work of the Limnoria exposes the burrow of the Xylotrya, the latter dies. No timber, commonly used for piles, is entirely immune from their attacks, although the boring is slower in the harder woods.

There being no way to destroy the borers, it is necessary to protect the timber in some way to prevent or retard their attacks and the following methods have been used:

1. Use piles with bark on. The borers will not attack piles with the bark on and this is one of the best methods to use, but as a very small exposed surface will permit of their attacks care must be taken to keep the bark intact while handling and driving. Where boats tie up to a wharf or where much drift is afloat it is impossible to keep the bark on. However, all piles driven in water infested by borers should have the bark on, unless given other treatment.

2. Use an artificial bark of sheathing. This method has the same advantages as natural bark and practically the same disadvantages.

3. Insert flat-headed nails to completely cover the parts of pile exposed to attacks. This method is very expensive and unless copper or galvanized nails are used they soon corrode and fall off.

4. Cover the exposed surface with fabrics saturated with tar or asphalt or mixtures containing them. This method is good while it lasts, but it will not last long in rough water or where boats or drift come in contact with it.

5. Cover the piles with copper, zinc or other metal sheathings. Copper and zinc are good, but expensive and are liable to be removed by thieves. Iron has to be thick to resist corrosion and is expensive.

6. Cover the piles with a cement coating, either before or after driving. In using this method it is customary to place wire netting around the pile with one to two inches of cement mortar, either applied as a plaster or by using a form and casting it. This method has been used with good success on tide lands where the mud is exposed at low tide and has also been used to protect and reinforce piles which have been partially destroyed. While liable to be broken off by drift, etc., it is easily replaced and can be recommended for such locations.

An additional objection to all of these methods is that no provision is made for increased depth of water, due either to scour or dredging.

Another method in use is to place a cement pipe around the pile with an intervening space of two or more inches which is filled with sand. This pipe is usually made in lengths of two to three feet and in pieces locked together, so that it can be put on a pile at any time without disturbing the cap. This method may be good in some locations where the water is smooth and no drift or boats are liable to strike the piles, but as a general thing it is doubtful if it will give satisfactory service.

The only other practical method is to inject poisonous substances or oils into the timber, either throughout the entire length of the pile or in that part above the mudline. The use of poisonous substances is not recommended as they require very careful handling and will leach out when exposed to salt water.

Very satisfactory results have been obtained from the use of creosote and the only objection to it is the expense. Often, on a pile 80 ft. long only 10 to 15 ft. will be subject to attack. In using the pressure process, the entire pile must be treated and this costs over $20 a pile, or about double the

cost of a pile untreated. If only 15 ft. could be treated this would not cost over $4 and would give as good service. This can be done by the open tank process and there may be some varieties of timber that will absorb enough creosote by this process to be satisfactory, but experience has shown that to successfully withstand the attacks of the borers every ounce of creosote possible should be injected into the timber. Consequently, where the borers are active and piles are intended to have a life of two or more years, we recommend that they be treated by the pressure process and creosote injected to refusal. With Douglas fir this will probably be from 12 to 16 lbs per cubic foot and with the pines from 20 to 24 lbs. Experience with creosoted timber resisting borers has shown remarkably good results although there have been some failures due either to insufficient treatment or to mechanical damage in handling after treatment. In handling creosoted piles to be used in salt water great care should be taken to prevent damage to the outer skin, either from holes made by cant hooks, or from checks caused by hard driving. Where piles can be placed with a water jet such a method is recommended and the use of steam hammers is better than that of drop hammers. Of course, drop hammers can be carefully handled and piles driven with them without damage, but there is always a temptation to drop the hammer too far.

While Limnoria always attack untreated piles from the outside, they will enter a creosoted pile through a crack and eat away the interior, leaving an outside shell filled with lace-like fibers. Xylotrya also work in creosoted piles if given a chance to enter.

The Southern Pacific has a wharf at Oakland, on San Francisco Bay, which contains 11,000 creosoted piles from 18 to 23 years old. Not one of these creosoted piles has ever been removed because of decay or from the attacks of borers, although the untreated piles used for fenders will not last over three years, and the majority of them are broken out in one or two years, almost every large steamer that lands breaking one or more fender piles. A few of the creosoted piles are being attacked at present due to their being split or checked but there is no doubt but that 90 per cent of them will last over 30 years.

At Port Los Angeles, the same company has a wharf containing 5,000 creosoted piles 23 yrs. old. The checked and split piles have been destroyed, but those not split or checked are still in good condition. One lot of 1,200 piles under a coal bunker was in first class condition for 20 yrs., not one pile being destroyed. A detailed inspection of these piles has not been made during the last three years as the wharf is not now in use. Untreated piles are destroyed in one to two years at Port Los Angeles. All of the piles in these two wharves are of Douglas fir 50 to 70 ft. long, creosoted with 10 to 12 lbs. per foot by the boiling process. Other companies have reported excellent results from creosote in other varieties of timber.

Fence Posts.

Fences are a great expense to railroads and satisfactory material for posts is difficult to secure. White oak, cedar and redwood are the most suitable varieties for posts and have a fairly long life as such. As they almost always rot off at the ground, it might pay to give the oak and cedar a butt treatment, but such is not necessary for redwood, which will probably be good for 40 years. The timber is somewhat scarce and of course is only cut in California. Oak and cedar are also becoming scarce and some substitute will have to be provided. Concrete and iron posts are satisfactory but expensive, and the real solution of the difficulty is in the use of any wood that may be available, treating it to prevent decay.

Practically all varieties of timber will give good service as posts if that part that goes in the ground and for about six inches above the ground is treated with preservative; but water oak, maple, sycamore, cottonwood, quaking aspen and possibly others should be treated full length, as they decay

rapidly above ground as well as below. A brush treatment is of some value but dipping the post in the preservative is better, as the checks and cracks are more likely to be filled. However, such treatment is only superficial and the results will not be as satisfactory as they would be if a more thorough impregnation is given. The open tank method of treatment is probably best for posts as the plant does not cost a great deal and it can be moved from place to place easily. Posts should be peeled and seasoned before treatment. Sapwood takes treatment better than heartwood and round posts are to be preferred, but the heartwood of a few varieties takes treatment quite readily and they can be split.

Wood Block Floors.

One of the best floors for shops and roundhouses is made of wood blocks, but the length of life is short unless they are treated with preservative. The blocks can be made of almost any kind of timber, but the closer grained pines and firs probably are best. They should be about 4 in. by 8 in. in size, from 3 in. to 5 in. long, and should be set with the end grain up. A light treatment of preservative is all that is required for floors in buildings and, as the blocks have such a large surface in proportion to their volume they are easily treated by the non-pressure or open tank process, using creosote, carbolineum and similar preservatives.

The best method of laying these floors is on a half-inch sand cushion on a concrete base 3 in. or 4 in. thick, filling the cracks with sand, asphalt or pitch. A cheaper method is to lay them on a half-inch sand cushion on a wooden floor of one-inch creosoted boards. The board floor is laid on the ground which has been graded and compacted with rollers or tampers and is used to prevent individual blocks from sinking into the ground if heavy weights are dropped on them.

Treated blocks are not recommended for freight house floors on account of the liability of damaging freight such as flour or sugar in sacks, etc., which might be piled on the floor. Blocks treated with chloride of zinc are not so liable to damage freight and, if blocks are used at all, this treatment is recommended. As the blocks would be dry no leaching would occur.

The best freight house floor is one of asphalt on a concrete base similar to asphalt street paving. Some such floors have been subjected to heavy trucking for ten years without sign of wear. The use of such floors would be a great factor in the conservation of our timber supply.

Wood blocks also make a very satisfactory floor for highway bridges and as paving for streets. For outdoor work they should have a full cell treatment of a preservative that will not leach out. This is important in that the full cell treatment prevents the absorption of water which would cause the blocks to swell and the pavement to bulge. The blocks should be laid on a sand cushion on a base of concrete or creosoted plank. Where the pavement is on a grade, it is better to use a cement and sand mortar between the blocks and the concrete base, on account of the liability of the sand being washed out by water running down the street, some of which will get through the cracks between the blocks. In laying blocks in mortar, the best way is to mix the cement and sand in the proper proportion (about one to three) and spread it dry on the concrete base, striking it off with a templet a trifle higher than the bottom of the blocks. The blocks are then laid close together in straight rows across the street. After a few feet are laid, they should be tamped with a tamper on a piece of 2 in. plank about 6 ft. or 8 ft. long. This prevents individual blocks from being tamped below grade. After all blocks are tamped, the entire surface is wet with a hose and kept wet for two or three days. Enough water will penetrate between the blocks to wet the mortar and cause it to set. The joints are then filled with pitch or asphaltum, which should have a melting point of about 150 degrees. It has been found to be most satisfactory to lay paving blocks at an angle of 27½ degrees with the curb, leaving about an inch space filled with pitch next the curb for an expansion joint.

Preservation of Ties.

The use of timber for cross ties has been one of the heaviest drains on the forest supply and there is no doubt but it will continue to be so while we have any timber left. It is true that the average price of ties has not gone up as much as was predicted a few years ago, but it is also true that the quality is not so good and there is a greater cut of the softer and poorer woods. Hundreds of patents for concrete ties have been taken out but it is doubtful if any of them are satisfactory, and it does not appear that the time is ripe for them. Steel ties are proving satisfactory in service, excepting that they are hard to keep insulated; but they are too expensive to compete with wooden ties at present prices. The question of tie supply has not yet reached a critical stage and, with the present tendency toward the use of preservatives it is doubtful if the time will ever come when timber will not be available for cross ties.

Cross ties fail from two causes, mechanical wear and decay, each of which has a great bearing on the other. The tendency at present seems to be to try to preserve a tie long enough to have it wear out before getting so badly decayed as to be unserviceable. It is probable that, with the usual track fastenings, a tie would wear out in about 20 years so as to be no longer fit for use even if perfectly sound; this applies particularly to heavy traffic lines. On light traffic lines, ties would probably last 50 years, except for decay. Instances are shown of cedar and redwood ties being in use 30 years or more, from which it would appear that a great deal can be done to preserve track ties by using improved fastenings, especially on heavy traffic lines. Tie plates are already coming into general use even with hard-wood ties and they have proven to be money well invested.

About one-quarter of all ties now used are treated with preservatives. In 1911, out of 135,000,000 purchased, 31,000,000 were treated as follows:

Creosote,	17,600,000
Zinc chloride,	8,600,000
Creosote and zinc chloride,	3,000,000
Miscellaneous,	1,800,000

A large proportion of those creosoted were treated by the Rüping and Lowry processes or what is known as the "empty-cell" method—the intention being to give as great a penetration as possible with a small amount of creosote. It is not expected that a tie so treated will resist decay as long as one treated by the full cell process, but it is believed that it will resist decay long enough to wear out rather than rot out. The principal objection to it is that there is some doubt as to all ties in a batch getting a good treatment, and the process is not adapted to all classes of timber. There is no doubt but that it is a very desirable and economical treatment when applied to the proper classes of timber.

Zinc chloride is cheap and that is probably its greatest recommendation. The life of ties is not greatly lengthened by its use, probably not over three years on an average, but this is long enough to make it pay even where untreated ties are cheap. The Allardyce and Card processes are used quite extensively for tie treatment and are giving good results. The Well-house process is also used but the number of ties so treated seems to be falling off from year to year. Ties are also treated with Carbolineum, using the open tank process. This method is largely used by electric railways and those treating a limited number of ties. The Santa Fe is using crude oil for preserving ties to quite a large extent, this process depending on the waterproofing of the tie rather than on any antiseptic quality of the oil.

Effect of Treatment on Strength of Timber.

The following conclusions on the effect of preservatives on the strength of timber are the results of experiments by the United States Forest Service:

1. A high temperature of steaming is injurious to the wood in strength and spike holding power. The degree of steaming at which pronounced harm results will depend upon the quality of the wood and its degree of seasoning, and upon the pressure (temperature) of steam and the duration of its application.

Fig. 2.—Treated and Untreated Timber Removed from Coal Bunker at West Oakland, Cal.

2. The presence of zinc chloride will not weaken timber under static loading, although the indications are that the wood becomes brittle after impact.

3. The presence of creosote will not weaken wood of itself. Since apparently it is present only in the openings of the cells, and does not get into the cell walls, its action can only be to retard the seasoning of wood.

(For the experiments on which these conclusions were based, see Forest Service Circular No. 39 revised, "Experiments on the strength of Treated Timber.")

Fig. 2 shows some of the timbers taken from the incline trestle leading to the coal bunker at West Oakland, which was constructed in 1895 and taken down in 1905. The piling and sills were creosoted and were in a perfect state of preservation when the trestle was taken down. The posts, braces and all upper work were untreated and this specimen shows the average condition of the upper work. The creosoting was done at the Southern Pacific wood preserving works at West Oakland in 1895.

Fig. 3.—Southern Pacific Pole Plant at West Oakland, Cal.

The sections of perforated piling show the work of the Teredo in Mission Bay, San Francisco, in 1½ years. The section badly checked was taken from a creosoted pile in the same locality put in at the same time which was broken by a steamer. Apart from injuries received by the steamer, the pile was in a perfect state of preservation. The life of an untreated pile in this locality is estimated to be a year and a half while well creosoted piling will last indefinitely if protected against mechanical wear.

Fig 3 shows the Southern Pacific pole plant at West Oakland, for treating the butt end of signal poles, etc., by the nonpressure process. Creosote oil is the preservative used and Douglas fir, cedar and redwood poles are being treated. In some parts of the south poles are treated throughout their entire length to withstand the moist climate.

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Committee.

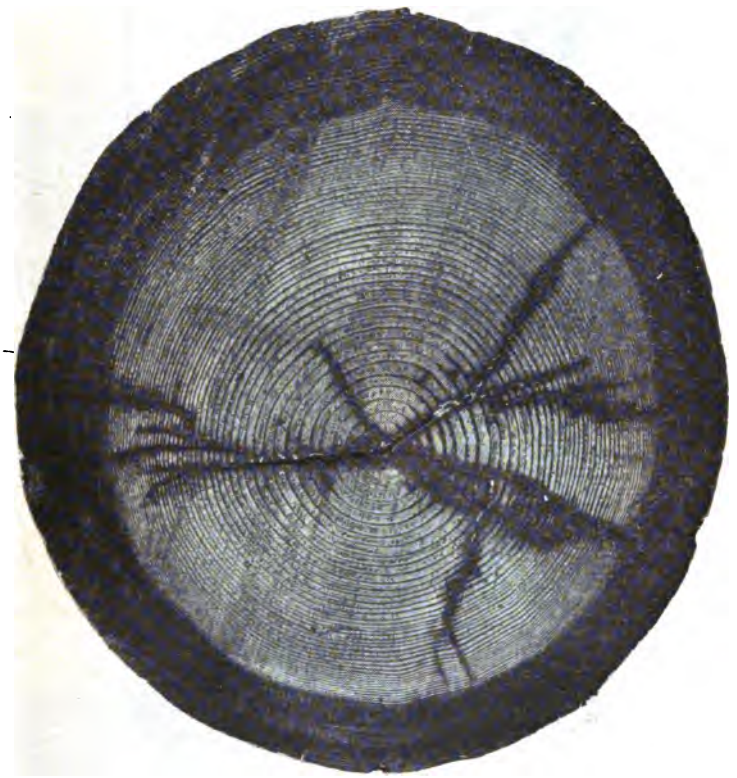


Fig. 4.—Section of Douglas Fir Pile Twelve Years Old Cut off at Ground Line. Treated by Boiling Process, 10 Lbs. Creosote per Cu. Ft. Southern Pacific Co.

Fig. 5.—Cypress Pile One Year in Salt Water in San Francisco Bay. (Attack of Limnoria on Surface).

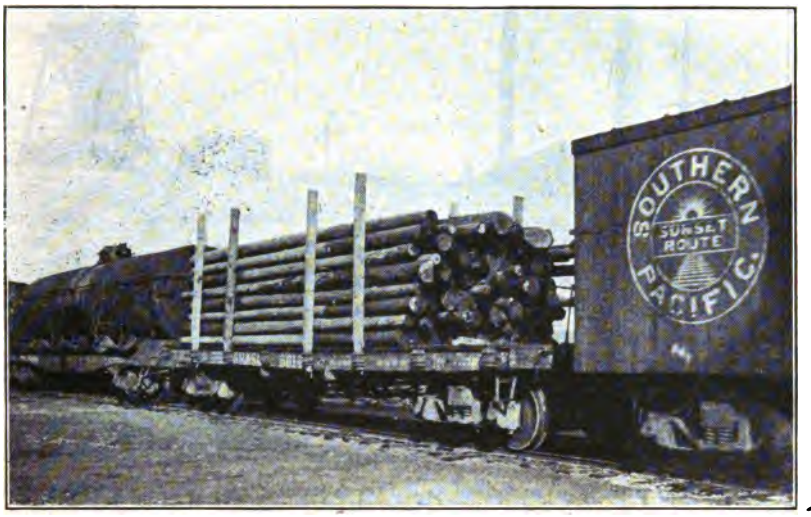


Fig. 6.—Car of Telegraph Poles,—"Butt-Treated" with Creosote.

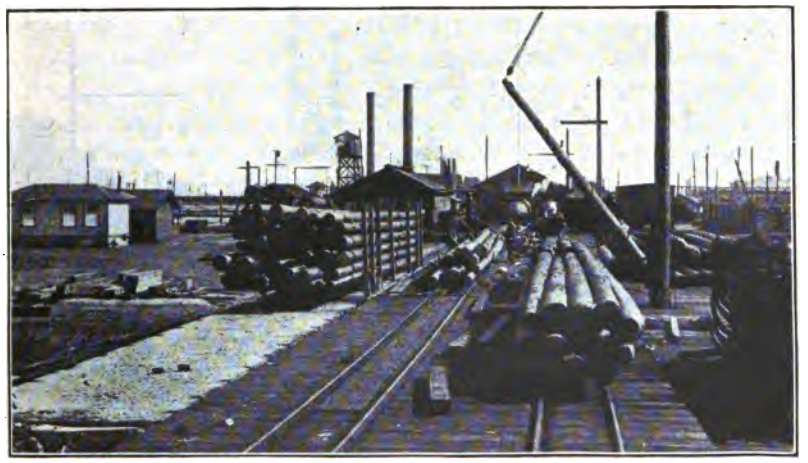


Fig. 7.—Discharging End of Treating Plant, Southern Pacific Co., West Oakland, Cal.

Fig. 8.—Charging End of Plant, Southern Pacific Co., West Oakland, Cal.

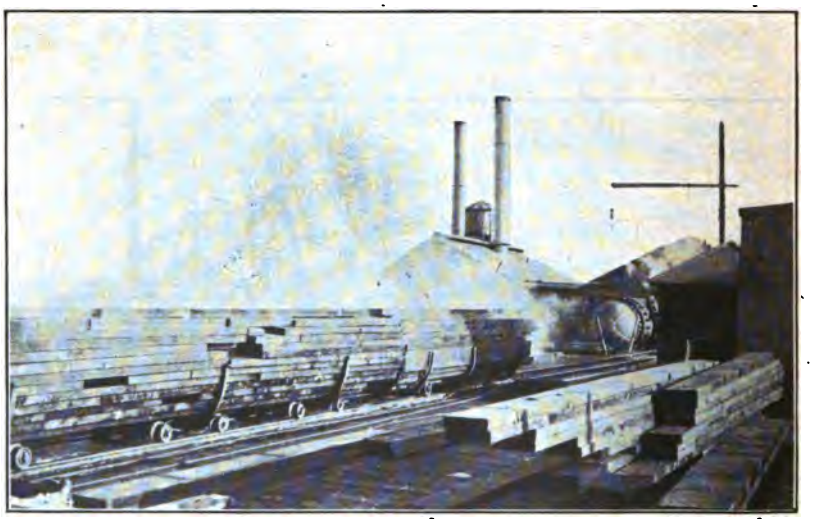


Fig. 9.—Discharging End of Plant, S. P. Co. Wood Preserving Works, Oakland, Cal.

Fig. 10.—Receiving End of Plant at Oakland, Cal.

DISCUSSION.

(Subject No. 11, Preservation of Timber.)

Mr. A. S. Markley:—I want to compliment the committee on this report; it is certainly complete and contains much information for us all. It makes reference to cypress piles; in that connection I will state that in 1899 or 1900 we were working in a cypress swamp in southern Illinois and were undecided as to the durability of cypress piles. In several tests we found that in driving them in water they were good for 10, 12 or 14 years, but they would not last more than four or five years in dry ground. These were untreated piles.

Mr. Rear:—I have letters from men on the Southern railway in which they state that cypress piles will last over 20 years, but that they do not use them on account of being too soft.

Mr. A. S. Markley:—We drove many cypress piles with a steam hammer after our last washout in March and April of this year and experienced no trouble in that direction.

Mr. Staten:—We had trestles with cypress piles in dry ground which rotted off in three years so that we had to cut them off and put on sills; but we have a creosoted pile trestle a mile long, near Old Point Comfort, part of which is 24 years old. We are just now beginning to go over this and replace some of the

worst piles. This structure was built with 4-pile bents with battered posts, two braces and 8 in. x 16 in. creosoted caps. Strange to say, those caps are all nearly as good today as the day they were put on, but the borers have started to work on the creosoted piles and braces so that we have taken out quite a number of them. We have a pile-driver working there now, picking out the worst piles and putting others beside them so as not to disturb the bents. This trestle has no heavy coal trains over it, but has heavy passenger service.

Mr. Sampson:—I was very much interested in the report of the committee. The members have gone into the subject very thoroughly and it is a subject that is sure to be of greater interest as the years go by. The lumber supply of the country is certain to diminish, and I think that one of the features of great interest is to see whether the creosoting process can be applied to those timbers which we now consider inferior and unfit for use in exposed places. Take timber like yellow pine, black birch, hickory and such trees as grow to large size and are suitable in length and diameter for piles, but which rot very quickly if put in exposed places. I have never seen any one who was ready to say that creosote could be successfully injected into any of these close-grained woods. I personally know of creosoted hemlock treated in 1881, in the state of Maine, which was bought for $12 per M and laid in a floor directly on the ground and which is in service today, almost, if not quite as good as it was when new. I remember distinctly the edge of a platform four feet above the rail built of chestnut posts 8 in. in diameter, 4 ft. apart, with an 8 in. x 8 in. spruce cap decked with this 3-in. hemlock timber. The line of that bulkhead is good today.

There is every evidence that creosote can be successfully injected into these cheap soft woods. I am also told that Carolina pine is better for creosoting than long-leaf southern pine. It seems to me that one great object is to see whether the creosoting process can be applied to these cheaper timbers that we now consider almost worthless. If a black oak tie is placed in the track its life is only three or four years at the best. If creosote can be injected into that timber I do not see why it could not be used as a good tie. I would like to know if any one present knows of creosote being applied to the cheaper grades of timber?

Mr. A. S. Markley:—When we built through southern Illinois in 1899 and 1900 we found a lot of black oak which is similar

to red oak. We built a creosoting plant at Mt. Vernon, and some of the ties treated there in 1899 are still in the track, or at least they were there a year ago. They would not last over four or five years untreated.

Mr. E. U. Smith:—I happen to know the manager of the Mt. Vernon plant and he tells me that they creosote the black oak and red oak ties, thus doubling the life of the ties.

Mr. Corbin:—I have in mind a place near Puente on the Los Angeles division where an untreated pine or redwood pile will not last over four years. A structure at this point was renewed with creosoted material 15 years ago and it is in good condition today. I also have the first creosoted timber put in on the Los Angeles division 17 years ago. I made a personal examination of this structure last year and found that it was in good condition, without any rot whatever. I know of redwood piles that have been in since 1888 in some localities on the Los Angeles division and are in good condition yet, but they are in exceptional ground and the condition of the ground has a good deal to do with the life of the pile.

Mr. Rear:—The committee might have gone into this subject much more extensively, explaining how some certain soils will rot a pile out in 10 years, while in other places they will last for many years; but with practical men as we have here, there is not much that we can tell them about the actual decaying of the material. We had to bring the subject to an end somewhere, and while the report is probably smaller than it might have been, I think we covered the ground as well as could be expected and with as few pages as possible.

Mr. E. U. Smith:—I would like to ask Mr. Rear how they creosoted the butt end of the poles shown in this report?

Mr. Rear:—This was done in an open tank, served by a derrick. We pick five or six of the poles up and stand them in the tank leaving them there probably four hours. The preservative is heated to nearly 200 deg. during the process.

Mr. E. U. Smith:—I wonder if this method can be applied to white oak ties and if the preservative will penetrate white oak?

Mr. Rear:—You will find most of that explained in the different processes of creosoting.

Mr. O'Neill:—The Lake Shore road has been creosoting soft wood ties for about nine years, but it does not creosote any white oak ties, as it is not considered economical. We find that no tim-

ber we get will take the creosote as well as the red oak ties and that the preservative will penetrate red oak better than any other soft wood. We treat maple and beech and in fact all the soft woods. One gentleman mentioned hickory; I do not think that we use any hickory as that goes for the most part to the handle factories in our part of the country. The committee explained the time that timber would last in different localities. I have had good cedar fence posts completely rot out in four years in one locality, while I have had them last 28 years in other localities. The location has so much to do with untreated timber that I do not think it would be practical for the committee to undertake to give the life of timber. All it can do is to give an average for the different localities. Even in the same locality we find places where although but a few miles away the life of the timber varies 300 to 400 per cent.

Mr. Staten:—The Louisville & Nashville has adopted creosoted frames for tanks altogether,—from the floor down. They bore all the holes and frame the timber as though it was an iron structure. They ship this all over the road and are using it exclusively.

Mr. O'Neill:—I have never used any creosoted frames but have one frame treated with carbolineum. It was applied hot with a brush,—one coat when the timber was ready to assemble and the other after it had been assembled.

That tank was put up in 1896. I had occasion to cut a hole through the bottom a few years ago,—after it had been up 15 years,—and it was apparently just as sound as the day it was put up. I can not see that with a wooden tank there would be much economy in treating the frame. With the exception of the bottom of the posts, where they come in contact with the stone or concrete foundations, our tank frames last fully as long as the top. We have to take care of the posts where they come in contact with the concrete or stone foundations, as they will decay there, but we simply splice them out.

SUBJECT NO. 12

CATTLE GUARDS.

REPORT OF COMMITTEE.

The committee was instructed to report on "Recent Developments in Cattle Guards;" hence it was considered advisable to restrict the work to modern cattle guard practice. The committee's interpretation of its instructions was such as to render unnecessary in its opinion any work of a historical character. Moreover, the general subject of cattle guards has been studied and discussed so thoroughly and extensively in the past, and the published proceedings of railway associations contain so much of valuable data and information that the committee construed its duty to be the preparation of material showing only the present-day practice and results to be accomplished in the light of recent experience.

GENERAL CONSIDERATIONS.

There are two principal and elementary characteristics pertaining to the installation of cattle guards: 1st, the necessity therefor; and, 2nd, type of structure. Necessity may be considered the result of two conditions: statute requirements and industrial economy; or, in other words, installation of stock guards may be required by the laws of the commonwealth or it may be necessary for economical reasons, in which latter case the second elementary characteristic, type of structure, has an exceedingly important bearing. Accordingly, inquiries, segregated as between legal features and physical features, were sent to officials of 127 railroads in the United States and Canada, each of these roads being over 100 miles in length. Replies were received from 75 railroads aggregating 134,239 miles in length.

LEGAL PHASE.

A compilation of the laws of the various states regarding installation of cattle guards was made in 1903 by the standing committee on "Signs, Fences and Crossings" in the American Railway Engineering Association, which compilation was published in the proceedings of that association. The committee considered it advisable to ascertain if any important changes had been made in the statutes of the various states since the date of the former compilation. Six questions were asked, as follows:

1. Do the laws of the states in which any portion of your railway is operated require the maintenance of cattle guards?
2. Do such laws require guards to be so constructed as to be a barrier against the roaming of sheep and hogs?
3. Do such laws absolve the railway company from responsibility for stock killed on its right of way, providing guards and fences are maintained in good condition?
4. In states which have railroad or public utilities commissions, do the statutes provide for approval by the commission of the type of guard installed?
5. Does such approval relieve the railway company from responsibility for stock killed on its right of way providing guards and fences are maintained in proper condition?
6. Do the laws of the states in which any portion of your lines are operated permit the roaming at large of stock upon public domain?

STATEMENT NO. 1.

DOMESTIC ANIMALS ON FARMS IN UNITED STATES
JANUARY 1ST 1912
NUMBERS EXPRESSED IN THOUSANDS

	CATTLE	HORSES	MULES	TOTAL CATTLE HORSES & MULES		SHEEP	SWINE	TOTAL SHEEP AND SWINE	
				NUMBER	%			NUMBER	%
Maine	253	108		362	0.44	186	101	287	0.24
New Hampshire	162	46		208	0.25	43	53	96	0.08
Vermont	436	84		520	0.63	117	111	228	0.19
Massachusetts	247	64		311	0.38	35	117	152	0.13
Rhode Island	34	10		44	0.05	7	16	23	0.02
Connecticut	191	47		238	0.29	21	60	81	0.07
New York	2389	609	4	3002	3.62	911	777	1688	1.43
New Jersey	218	91	4	313	0.38	30	165	195	0.17
Pennsylvania	1570	572	44	2186	2.64	883	1141	2024	1.72
Delaware	56	34	6	96	0.12	8	59	67	0.06
Maryland	287	163	23	473	0.57	230	345	575	0.49
Virginia	830	340	61	1231	1.49	781	880	1661	1.41
West Virginia	561	182	12	755	0.91	838	363	1201	1.02
North Carolina	692	173	182	1047	1.26	193	1405	1598	1.36
South Carolina	400	82	166	648	0.78	34	797	831	0.71
Georgia	1073	124	310	1507	1.82	174	2098	2272	1.93
Florida	881	52	25	958	1.16	120	954	1074	0.91
Ohio	1772	901	24	2697	3.26	3634	3578	7272	6.17
Indiana	1341	838	84	2263	2.73	1372	4031	5403	4.59
Illinois	2315	1497	151	3963	4.78	1068	4640	5708	4.85
Michigan	1507	634	4	2145	2.59	2276	1382	3658	3.11
Wisconsin	2650	652	3	3305	3.99	847	2051	2898	2.46
Kentucky	959	443	234	1636	1.98	1320	1724	3044	2.58
Tennessee	961	354	279	1594	1.93	762	1574	2336	1.98
Alabama	936	143	265	1344	1.62	140	1533	1673	1.42
Mississippi	1009	234	277	1520	1.84	214	1577	1791	1.52
Minnesota	2258	806	6	3070	3.71	600	1702	2302	1.96
North Dakota	718	691	8	1471	1.71	287	359	646	0.55
South Dakota	1260	675	13	1948	2.35	605	1104	1709	1.45
Nebraska	2615	1059	85	3759	4.54	382	4267	4649	3.94
Iowa	4166	1568	57	5791	6.99	1201	9689	10890	9.25
Missouri	2326	1095	333	3754	4.53	1755	4491	6246	5.30
Kansas	2570	1169	218	3957	4.78	326	2808	3134	2.66
Oklahoma	1746	750	272	2768	3.34	72	1410	1482	1.26
Texas	6211	1158	703	8072	9.74	2032	2544	4576	3.89
Arkansas	942	265	228	1435	1.73	134	1738	1872	1.59
Louisiana	804	187	134	1125	1.36	176	1642	1818	1.54
Montana	823	347	4	1174	1.42	5011	143	5154	4.38
Wyoming	603	159	2	764	0.92	4969	43	5012	4.25
Idaho	437	214	4	655	0.79	2951	212	3163	2.69
Utah	439	131	2	572	0.69	1990	79	2069	1.76
Colorado	1088	321	17	1426	1.72	1579	211	1790	1.52
New Mexico	953	185	15	1153	1.39	3300	50	3350	2.84
Nevada	449	72	3	524	0.63	1444	30	1474	1.25
Arizona	773	104	4	881	1.06	1510	22	1532	1.30
Washington	391	293	14	698	0.84	486	246	732	0.62
Oregon	637	289	10	936	1.13	2592	258	2850	2.42
California	2020	493	72	2585	3.12	2656	830	3486	2.96
Total United States	57959	20509	4362	82830	100.00	52362	65410	117772	100.00

As might be expected, these inquiries brought out a diversity of opinion as to the legal status in any one state. For example, several railroads operating in the same state answered the questions differently for that state, thus showing widely varying interpretations of the statutes therein. Closely coupled with the legal phase of the situation is the element of industrial economy. Generally, whether required by statute or not, stock guards are not so essential from an economical standpoint in regions wnere but few domestic animals are raised as they are in those districts where large numbers are kept. Statistics have therefore been compiled to show the relative importance in this respect of the various states in the United States and Canada. These statistics are hereto appended in Statements No. 1 and No. 2, the numbers of cattle, horses and mules being segregated from those of sheep and swine, for reasons which will later be made apparent. While it is true that some relation between the number of animals in any one state

STATEMENT NO. 2.

DOMESTIC ANIMALS ON FARMS IN CANADA
YEAR 1911
NUMBERS EXPRESSED IN THOUSANDS

			TOTAL CATTLE AND HORSES				TOTAL SHEEP AND SWINE	
	CATTLE	HORSES	NUMBER	%	SHEEP	SWINE	NUMBER	%
Prince Edward Island	112	34	146	1.53	109	46	155	2.90
Nova Scotia	333	69	402	4.23	351	70	421	7.88
New Brunswick	234	67	301	3.16	191	93	284	5.31
Quebec	1482	371	1853	19.47	533*	698	1231	23.03
Ontario	2793	791	3584	37.66	975	1470	2445	45.74
Manitoba	455	252	707	7.43	30	136	166	3.11
Saskatchewan	588	366	954	10.03	111	130	241	4.51
Alberta	1090	317	1407	14.79	179	149	328	6.14
British Columbia *	125	37	162	1.70	33	41	74	1.38
Total, Canada	7212	2304	9516	100.00	2512	2833	5345	100.00

* Year 1901. Later statistics not available

and the area of that state should in some manner be shown, yet it is evident that not much information of value would thereby be derived, for the reason that railroad mileage per square mile of area varies widely in the different states. These statements show the numbers of domestic animals in each state and percentage of national production in that state, of cattle, horses and mules in one group and sheep and swine in another.

To show the relation between production of domestic animals and statute requirements for stock guards in the various states, Statement No. 3 has been prepared. In this statement an endeavor was made to record from answers to Inquiry No. 6 the fact that stock may or may not roam at large upon public domain. Many replies from eastern states were to the effect that there was no public domain, but for this purpose the areas devoted to highways and dedicated to public use should evidently be considered public domain; and if stock is allowed to roam the highways unattended it is just at such highway crossings that guards are most needed. In several of the western states where large areas of public land are unappropriated there are no laws prohibiting the free roaming of stock, and this fact has an important bearing on the matter of guards.

It will be noted that while in the far eastern and far western states guards are not required to be barriers against sheep and swine, the middle and southern states almost universally require barriers against all kinds of stock.

STATEMENT NO. 3.

STATUTE REQUIREMENTS FOR STOCK GUARDS IN THE UNITED STATES AND DOMINION OF CANADA

	PER CENT TOTAL PRODUCTION IN U.S.		GUARDS REQUIRED BY STATUTE		STATUTES PERMIT ROAMING OF STOCK UPON PUBLIC DOMAIN
	CATTLE HORSES AND MULES	SHEEP AND SWINE	AGAINST CATTLE HORSES AND MULES	AGAINST SHEEP AND SWINE	
Maine	0.44	0.24	Yes	No	No
New Hampshire	0.25	0.08	"	"	"
Vermont	0.63	0.19	"	Yes	"
Massachusetts	0.38	0.13	"	No	"
Rhode Island	0.05	0.02	No	"	"
Connecticut	0.29	0.07	Yes	"	"
New York	3.62	1.43	"	"	"
New Jersey	0.38	0.17	"	"	"
Pennsylvania	2.64	1.72	No	"	"
Delaware	0.12	0.06	"	"	"
Maryland	0.57	0.49	"	"	"
Virginia	1.49	1.41	Yes	Yes	Yes
West Virginia	0.91	1.02	"	No	No
North Carolina	1.26	1.36	"	Yes	Yes
South Carolina	0.78	0.71	"	"	"
Georgia	1.82	1.93	"	"	County Option
Florida	1.16	0.91	"	"	Yes
Ohio	3.26	6.17	"	"	No
Indiana	2.73	4.59	"	"	"
Illinois	4.78	4.85	"	"	"
Michigan	2.59	3.11	"	"	"
Wisconsin	3.99	2.46	"	"	"
Kentucky	1.98	2.58	"	"	Yes
Tennessee	1.93	1.98	"	"	County Option
Alabama	1.62	1.42	"	"	" "
Mississippi	1.84	1.52	"	"	Yes
Minnesota	3.71	1.96	"	"	No
North Dakota	1.71	0.55	"	"	"
South Dakota	2.35	1.45	"	"	"
Nebraska	4.54	3.94	"	"	County Option
Iowa	6.99	9.25	"	"	" "
Missouri	4.53	5.30	"	"	No
Kansas	4.78	2.66	"	"	County Option
Oklahoma	3.34	1.26	No	No	" "
Texas	9.74	3.89	Yes	Yes	" "
Arkansas	1.73	1.59	"	"	" "
Louisiana	1.36	1.54	No	No	Yes
Montana	1.42	4.38	Yes	"	"
Wyoming	0.92	4.25	"	"	"
Idaho	0.79	2.69	"	"	"
Utah	0.69	1.76	"	"	"
Colorado	1.72	1.52	"	"	"
New Mexico	1.39	2.84	"	Yes	"
Nevada	0.63	1.25	No	No	"
Arizona	1.06	1.30	Yes	"	"
Washington	0.84	0.62	No	"	"
Oregon	1.13	0.42	Yes	"	"
California	3.12	2.96	No	"	"
Dominion of Canada			Yes	Yes	Yes

Note:-Where statues do not specifically mention stock guards it is very probable that fence laws are such as to render guards necessary. In states where there is doubt as to the inclusion of barriers against sheep and swine in the stock guard statute it is assumed in above statement that such guards are to be so constructed as to be barriers to all kinds of live stock.

Replies to inquiries No. 3, No. 4 and No. 5 indicate that there is no legal protection afforded by the installation of stock guards, and where stock is killed contemporaneously with the maintenance of guards in good condition claims are legally allowed on the assumption that the guards are not effective barriers, although in perfect order. It also appears that neither the approval of type by railroad or public utilities commissions nor conformity to statute requirements in design relieves the railroads from responsibility for stock killed. There would therefore seem to be no other alternative than the past practice of installing guards in strict conformity to local laws, allowing the matter of efficiency to rest with the available types of guards thus far devised.

Physical Phase.

To ascertain the present practice in installation and maintenance of stock guards the committee requested from the various railway companies answers to the following inquiries:

1. Do your standards provide for whitewashing or painting, in distinctive colors, stock guards or any of their appurtenances?
2. Does such painting or whitewashing, in your opinion, assist the device in its purpose of turning stock?
3. Do your instructions to the maintenance of way department provide for removal of track sections of surface guards during winter months, to prevent accumulation of snow and ice?
4. Are your guards maintained by track forces or by B. & B. forces?
5. Are you contemplating any changes in type or detail of your standard guard, and if so, to what extent?
6. Will you please attach hereto a copy of plan of your standard stock guard. If such plan is not available will you please mention trade name or designate type of guard used most extensively on your line?

Answers to these questions show that while the standard plans of 78.5 per cent of the mileage reporting provide for painting or whitewashing

STATEMENT NO. 4.

STOCK GUARDS
STANDARD PRACTICE IN TYPE AND MAINTENANCE
SEVENTY-FIVE RAILROADS IN UNITED STATES AND CANADA
AGGREGATING 134239 MILES

PRACTICE IN USE OF STOCK GUARDS	MILEAGE REPORTING	
	MILES	% TOTAL
No stock guards used	1206	0.90
Pit Guards	7473	5.56
Modified Pit Guards	16494	12.28
Surface Guards All Types	109076	81.26
Metal Surface Guards	30437	22.67
Tile Surface Guards	399	0.30
Wooden Surface Guards	76240	56.28
Guards Maintained by Track Forces	115343	85.92
Wing Fences Whitewashed	70924	52.63
Wing Fences Painted	1943	1.45
Guards Proper Whitewashed	22925	17.08
Guards Proper Painted	9581	7.14

guards or some of their appurtenant parts, yet the opinion of engineers is about evenly divided as to the efficacy of such coating in barring stock. It seems to be quite the general opinion, however, that at least the wing fences should be maintained in white.

Only a very small percentage of mileage reported a practice of removing track sections of surface guards during winter season. The maintenance of guards on 85.92 per cent of the mileage is performed by track forces, although on a portion of such mileage the installation of guards is effected by B. & B. forces.

In answer to Inquiry No. 5, a number of engineers replied that they were trying several late designs in an effort to determine the relative merits.

Replies to the inquiries have been summarized, as far as possible, in Statement No. 4, to which attention is invited.

One railroad reports it economical to eliminate guards entirely as fast as they need renewal, and some of the eastern lines report few guards in use because of recent track elvation or grade crossing elimination. It is to be noted that on a small percentage of mileage reporting, pit guards are still in use and that on a larger percentage some types of modified pit guards are standard. By far the greater mileage, 81.26 per cent of the total, employs one of the several forms of surface guard, and a decided preference is for a wooden slat design.

CONCLUSIONS.

After a study of the entire situation and thorough consideration of all the information at hand the committee begs to offer the following suggestions and conclusions:

Legal Status.—There has been recently very little, if any, change in the legal status of the matter. Where there are railroad or public utilities commissions the approval of such commissions of the type of guard installed does not afford protection in stock claims, nor does conformity to statute requirements effect any material advantage. Notwithstanding this fact an endeavor must be made to carry out both the spirit and the letter of the law, and in such effort that device of greatest known efficiency consistent with safety should be selected. Neither statute requirement nor the demands of social and industrial economy can be construed to justify the slightest sacrifice of safety in train operation.

Modified Pit Guards.—Realizing the effectiveness of the old pit guard, engineers have spent considerable study and effort in the design of a structure embodying therein only those features of the pit guard which are positive stock barriers without introducing the element of danger. The result is seen in the several types of modified pit guards, and while these all may be said to be thoroughly effective as barriers, it is questionable whether some of them have eliminated all possible chance of danger. For example, a pit with stringers and cross ties may be impassable for stock, but neglecting the matter of expense, the bridging of an opening eight or ten feet long in this manner constitutes at least a very undesirable structure in a railway roadbed. Moreover such a structure does not entirely avoid the possibility of holding fast on the track a frightened animal with broken or entangled legs.

A decidedly better construction, and one which is virtually as effective, is another type of modified pit guard consisting essentially of deep cross ties so spaced in proportion to their depth as to afford no knee room for an animal in taking a step. By making the cross ties of sufficient depth for barring the larger animals it also serves as a barrier to the shorter-legged animals, sheep and swine.

This type evidently embodies the correct preventative principles, for it neither injures the feet of animals nor presents the slightest opportunity for entrapping even the smallest hoof. The ties with chamfered upper corners are spaced by means of guard timbers sufficiently close to afford no unusually abrupt obstruction to the passage of derailed wheels. The main objection to the design would seem to be excessive cost of installation and maintenance. Nearly the same principle, namely that of preventing an animal

from taking additional steps even after having made one step, and allowing it to withdraw the foot without injury thereto, seems to have been the result sought in a few of the patented guards, nearly all of which have been abandoned because of practical considerations.

Metal Surface Guards.—Owing to a minimum of objections to surface guards from an operating standpoint, more attention has been given to their design than to any other type. In the various kinds of metal surface guards the principal recent developments consist in the use of devices designed to render the passage of an animal thereover impossible by reason of painful injuries inflicted on its feet. This is evidently an incorrect principle, since animals, unlike the human family, cannot be disciplined by example, and the desired result would apparently be more satisfactorily accomplished by the erection of a barrier so formidable in outward appearance as to be shunned by animals of every description. Almost all commercial types of metal surface guards have some serious inherent objections, and those which are somewhat effective in turning the larger animals are usually a menace in other respects.

Wooden Surface Guards.—It is doubtless due to the many well known objections and shortcomings of most of the metal surface guards that the wooden slat guard is used so extensively, and while some of the bad features and lack of universal efficacy of the metal is present in the wood, yet there are so many other desirable characteristics in the wooden slat type as to render it the best form of surface guard. Of late years the important changes in its design have had more to do with the method of attaching the slats to the ties rather than to any variations in general style. While there has been quite a diversity of design in cross-section of slat and method of packing, these differences are the result of practical and constructive considerations, and apparently do not have any material effect on the guard as a stock barrier.

Painting.—Various attempts have been made in the past to lend aid to the efficiency of stock guards by the use of different styles of painting, the object in view being an appeal to the natural instincts of animals to shun objects of strange or peculiar appearance. Not much success has attended these efforts, and while paint is sometimes applied to the guard proper as a protection to the material of which it is constructed, any kind of coating is almost universally limited to the aprons and wing fences. The futility of trying to maintain any part of the guard proper in distinctive colors is self-evident, while the general utility of maintaining aprons and wing fences in white will be instantly recognized. As between the use of whitewash and cold water paint for this purpose, little can be said in favor of whitewash, for even though the cost of the cold water paint itself be double that of whitewash, only about one third the number of applications are necessary to maintain the desired appearance.

In view of the foregoing observations, the conclusions of the committee may be summarized as follows:

1. Conformity to law in the installation and maintenance of stock guards is essential insofar as such conformity is a physical possibility without interposing any obstacles to the safety of train operation.

2. Climatic conditions, statute requirements, range laws and scope of animal industry all have a bearing on proper type of guard, and it would therefore seem impossible for any one design to satisfactorily meet the demands of the various localities.

3. It is more difficult to erect positive barriers against stock accustomed to roaming wide areas of public domain than against more thoroughly domesticated animals.

4. At the present time there is known no absolutely effective guard entirely free from objectionable features.

5. Elimination of objectionable or dangerous features usually necessitates a sacrifice of efficiency.

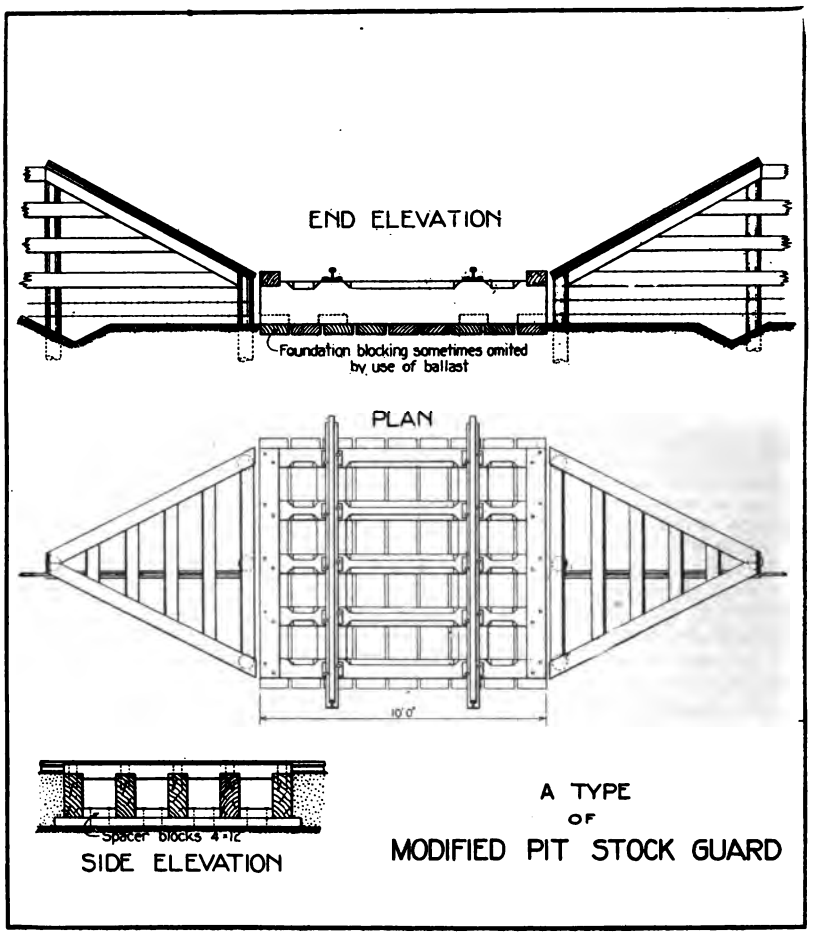
6. Wide variations in cost of installation, repairs and renewals, as well

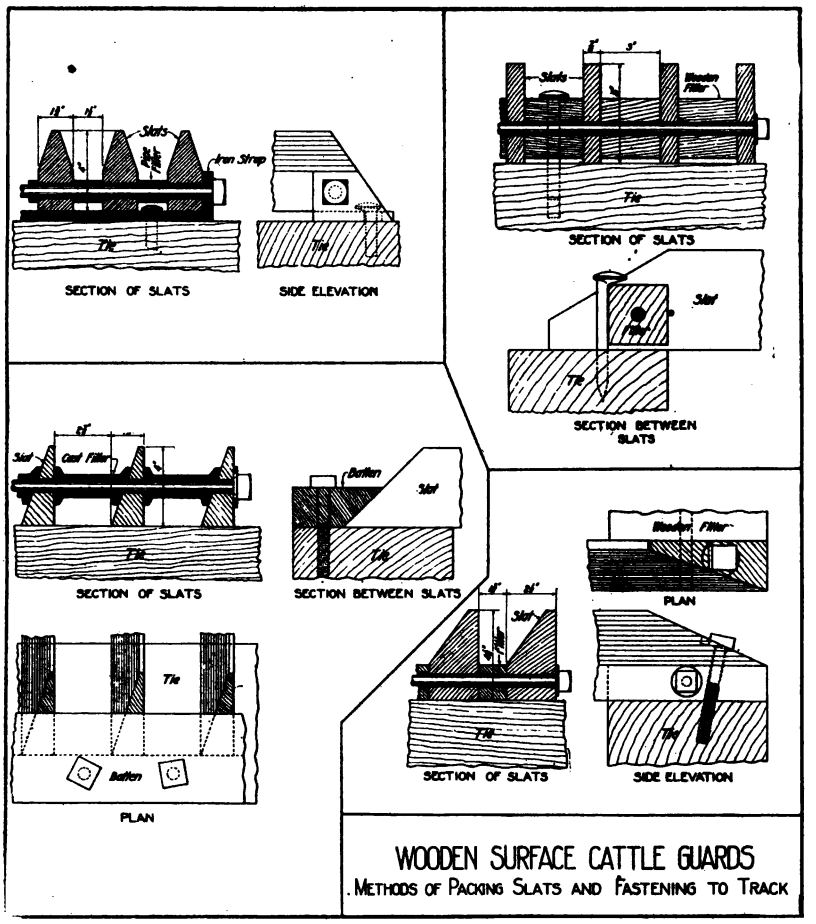
as in cost of general maintenance of track are possible without affecting the efficacy of the guard as a stock barrier.

7. Generally wooden slat surface guards embody a minimum of objectionable features and are probably just as efficient as most types of metal surface guards.

8. Aprons and at least the adjacent panels of wing fences should be maintained in white, and for this purpose paint is decidedly preferable to whitewash.

ARTHUR RIDGWAY,
Chairman.




Slats
Iron Strap
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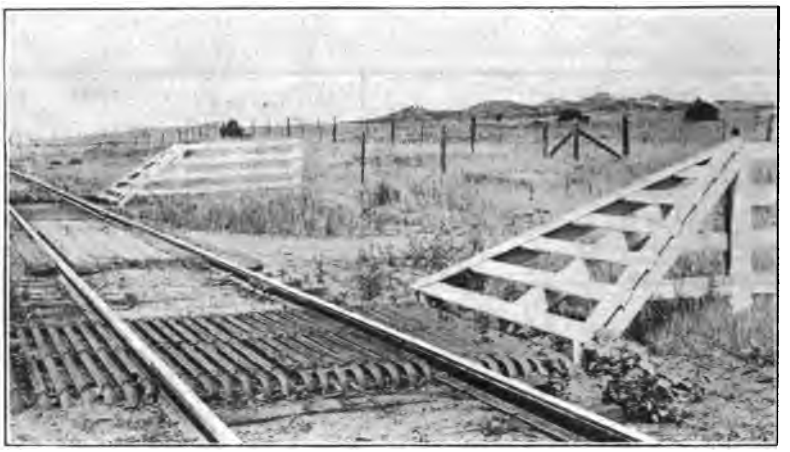
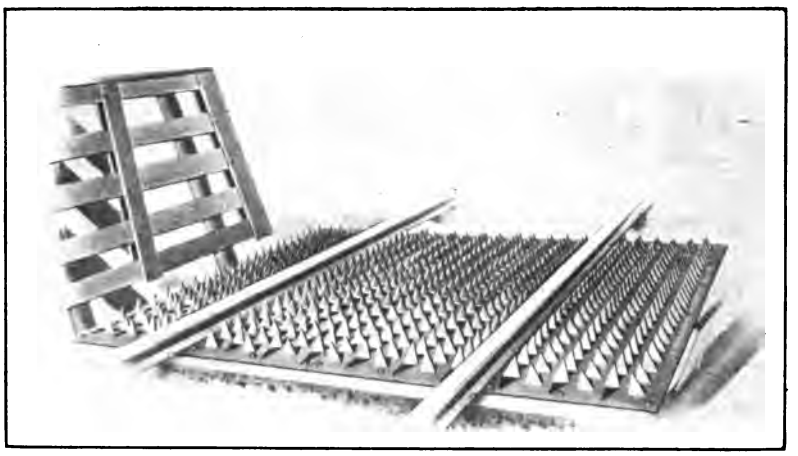
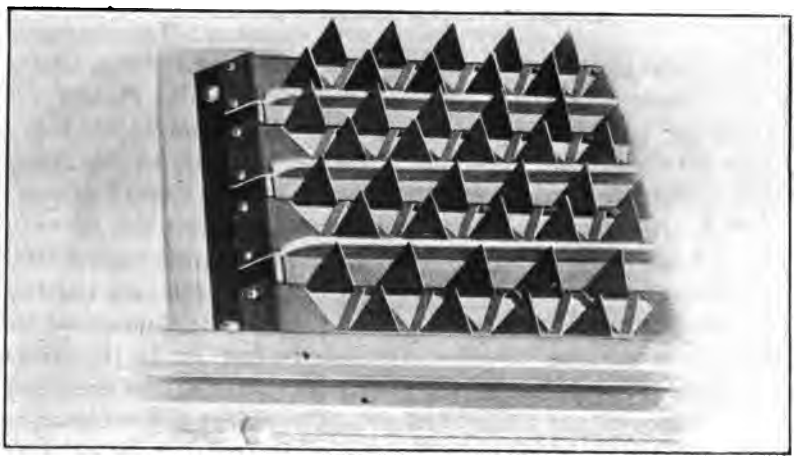
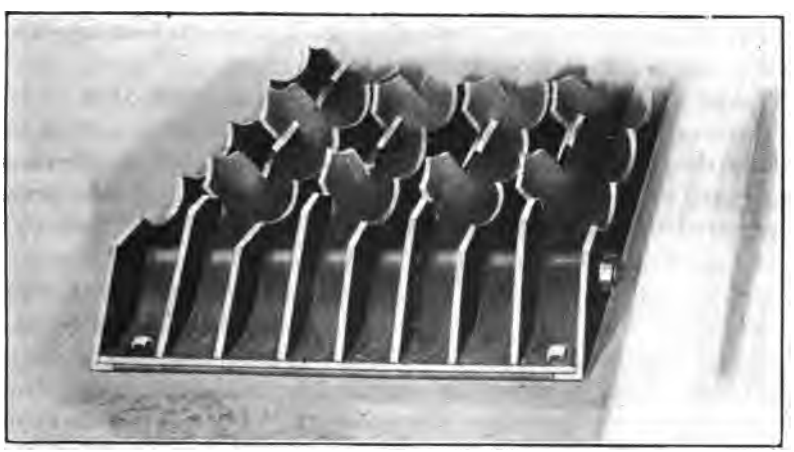
WOODEN SURFACE CATTLE GUARDS
METHODS OF PACKING SLATS AND FASTENING TO TRACK





Distinctive Types of Metal Surface Guards.





Recent Modifications of Metal Surface Guards.

DISCUSSION.

(Subject No. 12, Cattle Guards.)

Mr. Rear:—It always seemed to me that the opinion that a pit cattle guard was a very dangerous structure was greatly exaggerated. I have been connected with more than 12,000 miles of railroad for several years and never yet knew of a train going into a pit guard. I wonder if anyone else has ever heard of one? I think it is an undesirable structure and we do not put them in any more, although we are in a country where farms have 30,000 or 40,000 acres, with cattle roaming at large and are very hard to keep out. In towns and other civilized parts of the country where fences are maintained we use slat guards, but out in the wilds where the cattle run loose and nothing is in sight except the right of way fence we use a modified pit. We object a good deal to the modified pit with ties running crosswise, on account of their being so hard to keep tamped up to surface.

I understood one or two years ago that the Railroad Commission of Canada placed several feeds of oats on one side of a cattle guard and some cattle on the other side to ascertain how many cattle would cross over the different guards, but I never heard of any report of the test. Perhaps there is someone here who can tell us the result of those tests.

The President:—I can say something in regard to that. Several years ago the Department of Railways at Ottawa took up the cattle guard question, as there was a great deal of contention in regard to the best style of guard. They asked all who were interested to send samples which would be given a thorough test. They went through a form of testing with various kinds of cattle to find which guards they would go over and which they would not. There was one animal in particular, termed by the papers "The One-Eyed Steer," that passed over every style guard they had. Some of the animals hesitated before they went over some of the guards. The open cattle guard with eight or nine feet opening, the surface iron guard, cut in diamond shape with the points stuck up, and a large number of other styles were tested but when the tests were completed the matter was left just about where it started. The cattle guards on the Government roads are now nearly all being abandoned and filled. The

stock is not permitted to run at large as formerly, and very little attention is paid to guards.

Mr. Staten:—I got up a wooden guard once that was used at two or three different places. It was like one of the old outside shutters, in three pieces with the slats all turned one way to the center and the other way from there out with a piece in the middle. That would turn hogs and sheep better than any other kind I ever saw, but we never used them extensively, because the first time a brake beam or anything went dragging along it would tear them out.

At a roadmasters' convention several years ago a number of guards were tested out and the result was that the cattle passed over every style in the lot except the old pit guard.

Mr. J. H. Markley:—I notice that some of the New York Central lines and the Frisco lines are discontinuing the use of cattle guards. If there are any members here from those lines we ought to hear from them.

Mr. A. S. Markley:—We did so by common consent. We asked no one, but just simply tore them out and there was no complaint. The laws of Illinois are to the effect that stock should not run at large. If stock is found running at large it can be "pounded" and the owners are liable to a fine.

Mr. Rear:—It might be said in connection with this matter that the main objection to the old deep pit guard was the cattle themselves. An animal very often would get down in a cattle guard and about the time a motor car, hand car or train came along, make an attempt to get out, derailing the car or train. The reason a modified pit was adopted was so that an animal could not get down in them.

Mr. W. M. Clark:—With us the cattle guard is almost obsolete. In five years I have put in two sets of guards by request. The laws of Pennsylvania do not allow cattle to roam and do not require any guards, so we have quit putting them in. Of the two that I put in during the last five years, one was at the end of a tunnel and the other was at either side of a golf ground. I can not tell you why they were more necessary there than any place else. The laws are such that if cattle are killed on a crossing they must be paid for, but the small number of cattle running at large makes it more economical to pay for the few killed than to keep up a system of guards through a densely populated country.

SUBJECT NO. 13.

FIRE RESISTING COATINGS FOR TIMBER.

REPORT OF COMMITTEE.

At the St. Louis meeting, in October, 1911, it was voted to appoint a committee to make tests of preparations which claimed to have fire resisting qualities. The committee sent out inquiries for paints and received some 20 different brands. Late in 1912, ten dummy trestles were erected and covered with as many of the preparations, in accordance with instructions furnished by the manufacturers. By the time this was done the appropriation set aside for this work by the association had been exhausted and it was decided to erect no more trestles at that time.

The timber used in the structures was a good quality of second hand bridge material furnished by the Chicago & Northwestern railway. The work of building the trestles and applying the paints was done by the employés of the bridge and building department of the same road. These dummy trestles were built about 4 ft. high, measuring from the ground to the under side of the stringers. Each cap was half length, resting on two pile heads set in the ground. One set of three stringers, 8 in. x 16 in. x 8 ft., was placed on the caps upon which was placed a set of half length 8 in. x 8 in. ties. A 4 in. x 10 in. guard rail was then placed on one side, making the structure practically half of a standard pile bridge 8 ft. long so that the same conditions would exist for applying the paint and making the fire test as would obtain in actual practice. The structures were then allowed to stand until June 28, 1913, at which time the fire test was applied. Some of the coatings required but one application while the directions for a few recommended two.

The first test consisted of placing red-hot coals on the structures. No fires resulted from this. In the second test a moderate layer of hay was placed on top and beneath each structure and fired. In each case when the flame test was applied the flames rose rapidly and by the time the hay disappeared the fire had settled to a steady burn on the timbers. All of the trestles burned to destruction except one, and this structure had three coatings. The directions for this particular paint called for two coatings, which were of a different character, but after standing for some time after the application of the paints, the last coating seemed to have been washed off by the rain and the second coating was renewed which really made three applications. This structure withstood the test and the fire died out completely in about six minutes after being applied. It was later fired a second time and after burning slowly but steadily for a long time it too succumbed to the test. The committee was at a loss to determine if this particular structure would have stood the test had but two coatings been applied, or if any of the other trestles would have made a better showing if two or more coatings had been applied.

From the tests made it was apparent that none of the coatings could be properly termed fire-proof, but practically all of them were fire-resist-

ing to a certain extent, and that while in every case except the first test of the structure with three coats the fire gradually found its way into the timber, the paints could nevertheless all be considered as being of some value as fire retardents.

The weather conditions were quite favorable at the time the tests were conducted, being clear and bright with the mercury standing about 95 deg. in the shade.

The committee was disappointed owing to the fact that all of the trestles except the one were destroyed at the first application of the flame test. It desires, however, that further tests be conducted from time to time to ascertain if there are other paints on the market capable of making a better showing.

Some of the coatings were very difficult to apply, requiring 10 to 12 hours of one man's time to cover one of these small structures; in such cases the protection would prove rather expensive.

LEE JUTTON,
W. H. MOORE,
W. H. FINLEY,
C. T. MUSGRAVE,
J. S. ROBINSON,
E. S. MELOY,
Committee.

DISCUSSION.

(Subject No. 13, Fire-Resisting Coatings for Timber.)

Mr. J. S. Robinson:—Hot coals falling from the ash pans of locomotives and lodging in a decayed spot on timbers or dropping into the grass under bridges may result in a fire. We lost $16,000 worth of bridges in a very short time from such causes, where the timbers were untreated and unprotected.

Mr. Pickering:—In the section of the country where I am located many of the bridges are over streams and we are therefore not troubled so much with grass fires as we are where live coals fall upon a slightly decayed spot on ties or stringers, resulting in a total or partial loss. We have found by experience that a certain brand of fire resisting paint, so called, has in many cases —in fact I may say all cases, where it has been applied properly— stopped such fires entirely.

Mr. Rear:—It is not expected that any paint that can be applied to a structure after it is built can protect it from fire if the fire once gets started in it. In case of forest fires, one cannot save a structure. We had a tunnel burn out recently that the men could not save, on account of the extreme heat, notwithstanding the fact that grass and every kind of vegetation was cut away from the tunnel for more than 100 ft. The fire even jumped across the country road and burned a vineyard and green

trees. It is not expected that anything will save a structure from fire in such a case, but it is possible to apply something to a structure that will prevent it from catching fire readily and some of these paints are the remedies. One of the most effective measures to prevent a fire from burning a structure is to clean the grass away from around it. We insist on the grass being kept cleared away, and it would not be very well for a section foreman to cut it and leave it. We are bothered somewhat by tramps carrying grass in to make beds under structures and sleeping there, leaving the grass there to catch fire. We have never had a structure burned from catching on top, although we do have fires in our trestles from this source, notwithstanding the fact that we burn oil. The cause of this is the sparks from brake shoes, something that probably some of you will not believe but it is true. We have two or three places on long three per cent grades where trains run 25 miles with the brakes applied all the way down. In one instance the brake shoes of a passenger train got so hot that when the train stopped a shoe "froze" on the wheel and had to be cut off with a cold chisel, delaying the train three or four hours. In those places we paint the tops of our ties with red metallic paint, mixing the dry powder with oil. I think there is something in fire-resisting paints, but it would be better to call them fire-preventative instead of fire-resisting paints.

Mr. Reid:—I would like to ask if anyone has ever tried a mixture of whitewash with alum water? I never used it myself, but I have heard it recommended as a fire-resisting preparation.

Mr. Aldrich:—In our section of the country the trouble is mostly with coals from the fire boxes, and I think that in our densely populated country, something that will retard a fire for a short time will be a great benefit. That is the reason I wish to call attention to whitewash. It will retard a fire enough so that in 99 cases out of 100 we will not lose anything, as somebody will see the fire and put it out before it does much damage.

Mr. Pickering:—Mr. President, I agree with Mr. Aldrich that whitewash is a deterrent to fire, but I question the advisability of applying it to exposed structures, as I hardly think the benefits will warrant the expenditure, for the reason that it costs very nearly as much to apply a coat of whitewash thoroughly, or probably I should say two coats of whitewash,—for one is hardly effective,—as it would to apply one coat of fire-resisting paint.

Where the whitewash is exposed to the weather, the life will be quite short, while the fire-resisting paint that we have used is good for at least five years. I will say, however, that on some of our branch lines we have whitewashed the interior of some bridges and invariably found that the whitewash is a very good protection against fire, and as it is not exposed to the weather, it will last for many years. However, where it is exposed to the weather I would recommend fire-resisting paint rather than whitewash.

Mr. Aldrich:—In reply to Mr. Pickering I will say that it does not cost nearly so much to apply whitewash as fire-resisting paint. One can apply whitewash with a sprayer for half what he can apply the paint. I will admit that whitewash is short-lived out of doors. Two years is about the extent of its life, but the actual cost of whitewash is very little; one can buy a barrel of lime for 90 cents.

Mr. J. S. Robinson:—I think the fire-resisting paint can also be applied with a sprayer with compressed air. Of course it would be more expensive, because the fire-resisting paint costs more than whitewash.

Mr. H. U. Smith:—We have tried this fire-resisting paint on our road as we have had much trouble with structures catching fire from the fire-box. Some of our bridge structures have caught fire along the stringers. In one instance recently a structure was burned for about ten feet. Fortunately the section foreman happened along and put it out, otherwise the structure would have been entirely destroyed. We do not seem to have any trouble with structures catching fire from grass.

Mr. Ettinger:—It appears to me that in cases of this kind we sometimes draw on our imagination. A man comes along with what he ought to call a fire-retarding coating but he will call it fire-resisting. It has been acknowledged everywhere that a coating of almost any kind will retard fire to some extent. Is it really fair to any coating to ignite a large amount of hay, shavings, wood or anything of that kind, under an old wooden structure which burns like tinder, and call it a fair test? Would anybody expect a coating of any kind to stand under such conditions? Yet the fact remains that if one paints a shingle roof, for instance, on a station building with any kind of paint and adds powdered alum, the alum will not retard the fire but it makes the paint fire-

resisting or fire-retarding, because it slates up, and anyone knows that a surface with a hard top will not catch fire as quickly as one that has "hair" on it ready for the match. We ought to be fair with our tests. Where will a structure stand under any condition when tramps set fire to a bunch of dry hay under it? Nothing will stop that. There are preventative coatings that will retard fire to some extent. Some manufacturers use chemicals. The moment a fire starts on the structure this chemical comes to the surface and forces itself ahead of the fire until by and by the resisting hard coating will cause it to burn out.

The idea that a structure of any kind 10, 20 or 30 years old and partially decayed, coated with whitewash or paint, can stand hay piled beneath it and fired is unreasonable. In the inaccessible parts that the sprayer and the brush will not reach is where the tinder lies and if a small red hot coal gets in there, the structure will go. A chain is no stronger than its weakest link and it is just so with these paints or coatings. If a certain spot on a structure is not coated, and a fire starts in that weak spot, it is bound to go. I believe that we ought to be reasonable with ourselves, and not say that we have found nothing that will resist fire because our paints that we apply daily will to some extent resist fire as has been proven time and again.

Mr. Robinson:—During the tests I observed that the rotten spots in timber treated with the paints were the last to burn and I attributed that to the fact that they absorb more of this fire-resisting solution than the good timber. Of course, if the timber was not treated the decayed spots would be the first to catch fire.

Mr. Pickering:—In answer to Mr. Ettinger's statement regarding the inaccessible points that whitewash or the paint do not reach, I would like to give briefly a little description from my own experience. I have a double track, pile bridge, where the service over it is practically during the daylight hours, a 15-minute service over each track. A year ago last August, after we had a very dry spell, with no rain for perhaps six weeks or two months, I received a message that that bridge was on fire. The nearest crew that I could send could get there in about half an hour. I telegraphed them at once and they went there. When they arrived the fire had almost died out. This fire started on the under edge of a tie that had become decayed very close to the track stringer; the tie was decayed when painted so that they

had not applied the paint under the edge of it. The fire started here and as soon as it got up on the tie to where it had been covered with the fire-resisting paint two years before the resistance was sufficient to stop the burning of the tie and the structure was saved.

Mr. Reid:—The point has been raised as to the test being very severe. Tests must be necessarily severe; they must be made in a short time, under conditions that would ordinarily take a long time, and the committee is not in a position to prove these facts but we do get the same conditions occasionally under our structures; not only the grass that grows there, but weeds, paper, etc., do collect there, especially in swampy places and catch the sparks which drop from locomotive fire-boxes. Referring to the suggestion that the timber was second-hand or old timber,—possibly 20 or 25 per cent of the bridges in the country are comparatively old bridges. Necessarily the bridges are not all renewed every year. The average life of the timber bridges on the Lake Shore road is probably 15 or 16 years and the larger part of them are old structures. In the case of the fires we have had it has been the old bridges which have burned. The new bridges don't take fire so readily. I think all these things should be taken into account. I don't think the committee had an idea that any of these so-called fire resisting paints would prevent a bridge from burning with the fire under it, but I believe their idea was to find out which paint would prove the best deterrent. I think their report is along that line.

Mr. Alexander:—I heard Mr. Reid mention something some two years ago about the preservation of wood by painting with carbolineum and he said they used it on his road considerably. We have done that too, putting on what we call "woodolin," which is similar. We use it on bridge floors, for the purpose of preserving the wood as we think that anything that preserves the top of a tie and the top of a guard-rail is fire-resisting to an extent, because if the wood does not decay, it will not take fire so quickly. The result of this treatment has been that it has preserved the surface of the wood and the wood we treated ten years ago with woodolin has not one rotten stick in it yet. The same is true where we used carbolineum.

Mr. Ettinger:—There is one more question that ought to enter into that report: The question uppermost with chief en-

gineers and general managers is, will the cost of applying a fire-resisting coating of any kind really offset the fire losses on our railroads of the present day?

The Secretary:—I do not think that it is so much a question of the loss of the structure itself as it is the inconvenience of losing the bridge and the delay to traffic resulting therefrom.

Mr. W. M. Clark:—Besides innumerable small fires, this last year, on the division where I am located, one bridge 212 ft. long was entirely consumed and we lost 196 ft. of another bridge, tying up traffic for about 36 hours while both structures were being rebuilt. I imagine that the cost of these two structures, plus the inconvenience and the loss of traffic for that length of time, would have applied a great deal of fire-resisting paint. I saw a statement from our superintendent of insurance some time ago and it is my recollection that our fire losses on bridges alone for a period of six or eight months in the year 1913 was something over $20,000. I think if we have a fire-resisting paint it will pay us to apply it.

Mr. Reid:—The question of the relative cost of fire-resisting paint and of the structure itself is evident. I think that is a matter for each road to determine for itself. The report has been submitted and I think we can leave it to the various railroads to decide for themselves where they want to use it and where they think it is not worth while. I do not think it is advisable for us to go into all the details of this subject in this convention, because we could spend much time on it and would not arrive at any definite conclusions.

Mr. Beard:—We applied fire-resisting paint on a 5-span bridge in my territory a year ago. We experienced continual trouble with this bridge on account of fire and it was in a rural district where we were afraid it would burn before anybody could discover it. Since we applied fire-resisting paint there has never been a fire on it. I have gone there many times and found hot coals that had dropped from an engine. If the material which it was painted with had not been fire-resisting it would have burned. Previous to the application of this paint we had as many as 9 fires on that bridge in one week. In another instance I had just completed the work of putting 250 new creosoted ties on a 4-span bridge over the Schuylkill river, when at four o'clock the next morning I received information that the ties

were on fire. When I arrived at the bridge I found all of those creosoted ties were destroyed. The main question is not so much the loss of the material destroyed, as it is the interruption to traffic. My argument is that if fire-resisting paint is properly applied, one don't have to paint the timbers underneath as the trouble is on the top of the tie in nearly all cases. I think the best fire-resistant is to get the motive power people to educate the men to stop dropping hot coals on bridges.

Mr. Swartz:—In this connection I may say that we have in our territory steel bridges with wooden ties. We have renewed two of those bridges this summer and are now working on the third. The ties are yellow pine and were placed in 1903 to 1905,—so we have had only 8 or 10 years' service out of them. After I saw the test at St. Louis two years ago I believed that if we covered these decks with this or some similar paint that would resist fire, we would probably not only protect the structures against fire but in all probability would preserve the life of our decks. During the summer an engine passed over one of our bridges and set fire to the ties in 50 places. Fortunately a short time later another train passed in the opposite direction and put the fires out. We will be glad to see this discussion come before the managements of our various roads to help us get something that will not only act as a preservative but also protect the timber from fire.

Mr. Staten:—Everyone is interested in the question of trestles burning. In the test at St. Louis, that paint had been applied only a little while. If it will last four or five years, it will pay well to put it on. Everybody connected with the road has an idea about it. Some people on the road made us cover everything with galvanized iron. We fitted it in the best we could, but a trestle caught fire and nearly burned down before we could get the iron off to put the fire out. That iron cost more than all the paint we could have put on. We don't want to paint the whole structure but only the tops of the guard rails, stringers, ties and caps. If that is cheap enough and will last long enough to show up like the paint did at St. Louis it will pay us to put it on any railroad trestle.

Mr. Watson:—I treated a trestle over 1,300 ft. long with fire-resisting paint four years ago. The month previous to painting this structure it had been on fire three times and on one occasion

had delayed trains six hours. We painted that structure with fire-resisting paint and it never has been on fire since. The fires were caused by coals dropping from locomotives. This was an old structure over tidewater and had been built 20 years. We drove intermediate pile bents but the top was so good that we decided to let it remain. We turned the ties a quarter over and left them forming an excellent place for fire.

Mr. Pickering:—Our report should have shown something about the comparative cost of applying these various paints. The first thing our management will ask us, if we are in favor of fire-resisting paint is, " What does it cost? "

Mr. Ettinger:—The report does state that, Mr. Pickering.

Mr. Pickering:—It does with reference to the labor but it seems to me that it should state the approximate cost of applying a coat of fire-resisting paint per lineal foot of single track trestle.

Mr. Staten:—We try to keep three or four water barrels on each of our trestles. They cost $1.50 or $2.00 each. While we depend on their being in place the boys will come along and push them off, so we fasten them down and fill them with rocks. If a structure is covered with some kind of paint, one does not have to depend on a water barrel and an engineman or section man to fill it. I find that at a fire the first thing to burn is the water barrel. I tell the supervisor to send a barrel there. He says, " We have no barrel and will have to get it from the storekeeper so will have to wait for it." We believe we can protect those structures with paint better than with water barrels. It is a surer way and cheaper in the long run. Barrels are a nuisance.

Mr. A. S. Markley:—Is it not a fact that most of the fires start on top of the caps and between the stringers and the ties? It has been our experience that wherever we have a fire it is at the cap, and if paint can be applied there it would be a good thing. The local conditions must be considered whether it pays to protect bridges or not. If there are frequent trains, and residents live near by so that fires can be put out these facts influence a decision whether it will pay to go to the expense. If the bridges are remote from civilization—where people seldom see them, and where trains are few—a structure may burn out before anyone detects it. I believe that we have spent less than $150 in the

last two years in repairs to trestles damaged by fire, and we have in the neighborhood of 6,000 to 8,000 ft. of timber trestles.

Mr. Pickering:—I disagree with Mr. Markley in his first statement. Fully 75 per cent of the fires on our bridges start either on the top of the stringer or the tie. We seldom have fires start on the top of the cap. However, fire-resisting paint can be applied where he says his fires start as readily as to any other part.

Mr. Aldrich:—Many times I have seen a mark on new timber where a coal had dropped and burned a small hole, perhaps a quarter of an inch, and gone out of its own accord. According to my recollection we never have lost any part of a new trestle by coals dropping on it and burning. The fires invariably start in partly decayed portions of the timbers. I aim to keep decayed spots cut off, but I am of the opinion that a fire-resisting paint, even if it resists but a little, is a good thing and I am in favor of it on top of trestles.

Mr. Ettinger:—I want to say one word before we lose sight of the main question. The question has been raised regarding the durability of the paint. This recalled to my mind a case about ten years ago, when I made a test on some fire-proof paint which at that time was quite new. We built a little shed and after five or six months, we burned it. However we saved six or seven boards from that shanty, and I have one of them yet. The paint had entirely disappeared from those boards and it occurred to me some time ago to make a test on the several that I had left. I found that while the coating had entirely disappeared the fire-resisting qualities of the chemical were still present and it resisted the fire just as much as it did when the coating was there. This proved to my mind that some of these fire-resisting or fire-retarding paints apparently are indestructible. Of course I don't know whether that is true of all these paints or not, but I do know it was with this particular paint.

Mr. J. S. Robinson:—If we are going to make recommendations that the managements of the railroads will see, I would say that the first recommendation we ought to make is to have the grass cut away from the bridges and all wooden structures. I found a wooden box culvert this year with water running through it, but the weeds had grown around it so high during the hot weather that a spark fell into those weeds and set fire to them

spreading to the culvert and going entirely through it. The culvert had been in about twelve years and the fire almost completely destroyed the top and sides down to the line of dampness. As far as fire-resisting paint is concerned, I think about 15 years ago we applied a paint and sanded the tops of our caps. This season we found some of those caps on a structure that has been there 16 years where fire had burned quite large holes in some of the newer caps, but on those caps that were sanded and painted with this common paint, we found that the fire had not touched any of them. I think that any cheap paint put on and sanded will resist fire. I think one of our recommendations ought to be that some kind of coating be put on our bridges to resist fire. Why not recommend repainting or recoating every three years, if we find any places that need recoating?

Mr. Cole:—In 1911 and 1912, we painted about 75 bridges with fire-resisting paint. Previous to that you might say it was a weekly occurrence to have fires; since that time we have not had one fire.

Mr. Conn:—We have very high trestles and are very much afraid of fire. We get all of our ties dressed on the top side and the guard rails dressed all around, and we give all of our new bridges that we put up now, a coat of paint. The bridges are steel. After painting the structure, the last thing we do is to coat the deck. Since we have done this we have not had a single fire. Previous to that, ten years ago, I had two bridges about a quarter of a mile apart. One was painted and one was not. Shortly after they were put up, we lost about 25 feet of the one that was not painted, and we would have had a serious wreck except for a farmer living close to the trestle, who put the fire out. I think that any kind of paint one can put on is an improvement to the bridge. If a deck is put on in the summer time, it is practically green timber and will check and open up and so is more apt to catch fire than if it is painted. We have no wooden trestles but we have what we may call T-walls on girder spans. We use wooden stringers here and cover them with 16-gage galvanized iron. This will prevent fire, but if one gets afire, it is difficult to put it out because a draft is formed that runs along under the galvanized iron. However we hardly ever have one catch fire. I knew of one to catch fire about five years ago at the timber bulkhead at the end, but it burned only one tie. We have not had a fire on my division for years that would amount to any-

thing except this 25 ft. of trestle. We use common paint, costing about $1.30 a gallon.

The President:—On the Intercolonial all bridges of over 20 or 25 ft. span have 42 gallon casks filled with water sunk about two-thirds their depth into the ground at each end of the span. Usually that water will remain there nearly all the summer. In the fall of the year, of course, the water is taken out. In going over the road for 14 or 15 years I have seen but very few cases where fire had started on any of the bridges and none of the decks had been burned. We have no trestle bridges, they are all of steel and stone, but the decks have wooden stringers and a fire will originate in the 4-inch space between the ties. I have seen a few cases where they have caught but as water was handy fires have always been put out and no damage has ever been done. The water barrels are considered of the greatest importance with us. All the new bridge decks are of hard pine coated with carbolineum and even after the carbolineum is apparently gone the fires don't start, while the timber is preserved as well.

Mr. Beard:—What method do you use in putting the water on the fire?

The President:—A special bucket is made that is no good for anything else, so that it won't be taken away. This bucket has a round bottom and is sunk down into the bottom of the barrel where it can be reached at any time.

Mr. Beard:—We have a place with five water barrels; I had two buckets made for each barrel, but when we wanted to use them, all the buckets were in the Schuylkill river.

The Secretary:—I think we will all agree that water barrels are expensive, and where fire-resisting paint is used they may be dispensed with. While fire-resisting paints may not be effective in all cases against grass and forest fires I believe that it is a good plan to coat the top side of timber on bridges wherever it is likely that hot coals will be dropped. It has been demonstrated many times that red hot coals dropped from locomotives, in experiments as well as in actual practice, will not set fire on timbers that have been treated with fire-resisting paint. Such paints have a preservative effect as well. I am in favor of going on record as recommending this practice, and I move that the chairman appoint a committee of three to prepare recommendations for our

approval, which may be included in the proceedings at the close of this discussion.

Motion seconded and carried.

The President:—I will appoint on that committee, B. F. Pickering, J. S. Robinson and R. H. Reid.

RECOMMENDATIONS ADOPTED.

Some brands of fire-resisting paints if properly applied, are quite effective as they afford considerable protection against fire from coals and sparks on the decks of structures. Where they are used it is hardly necessary to maintain water barrels which are expensive and unsatisfactory. These paints also have a decidedly appreciable preservative effect upon timber as regards decay. We therefore recommend their use for decks of wooden structures. We also recommend that great vigilance be exercised by section men and others in keeping grass and all inflammable matter cleaned away from beneath structures, and that chips and other inflammable material, including decayed wood, be kept from the tops of bridges.

(Signed by the Committee.)

PROTECTION OF CONCRETE IN SEA-WATER. BETWEEN HIGH AND LOW TIDE.

By William B. Mackenzie, C. E.

Right of Way and Lease Agent, Intercolonial Railway of Canada, Moncton, New Brunswick.

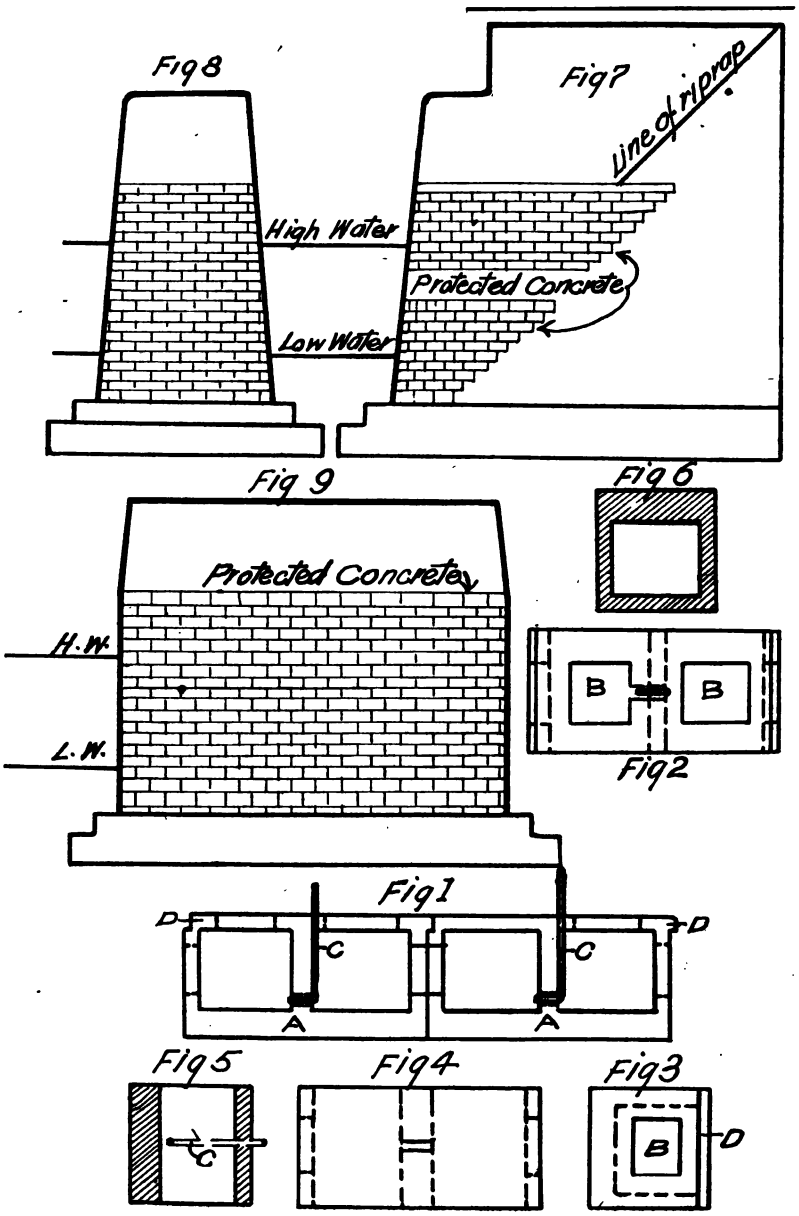
The accompanying photograph is a typical example of the deterioration of concrete in sea-water, when exposed to wetting and drying, freezing and thawing, in the intertidal space, in Northern latitudes. The rate of destruction between A and B was ½ to ¾ in. per year, after about the third year. This wall has been repaired twice: the first time with vitrified bricks, but they were not carried up high enough and the waves reached above them. It was further repaired in 1911 by adding four tiers of small concrete blocks, of one part cement and two parts sand set in air. The vitrified bricks have remained in perfect condition. The concrete blocks placed in 1911 are already showing signs of damage, although the quality of the concrete below low-water and above high-water is first class. I have observed that where sea-water is mixed with fresh water, to the extent of say 50 per cent as at the mouths of rivers, or in arms of the sea projecting far inland, the rate of destruction is considerably greater than in sea-water alone.

This protection consists of a combination of vitrified salt-glazed hollow clay tile blocks, built in with the concrete structure, and forming an outer shell to protect the inner concrete structure from contact with the sea-water or the atmosphere, and to completely protect it also from frost and wave action. The blocks are pressed through a die, in a manner similar to the ordinary building-blocks, but are of greater thickness, and are further furnished with large openings in the sides and ends, so that the wet concrete runs into the blocks by gravity as they are built up into a wall slightly higher than the mass of concrete which they enclose. Usually, the block wall forms the mold for the concrete body, iron tie-rods being used to prevent it from spreading while the concrete is wet. When completed, the blocks become an integral part of the structure itself, and the whole presents the appearance of a tile block construction, as shown in Figs. 7, 8 and 9.

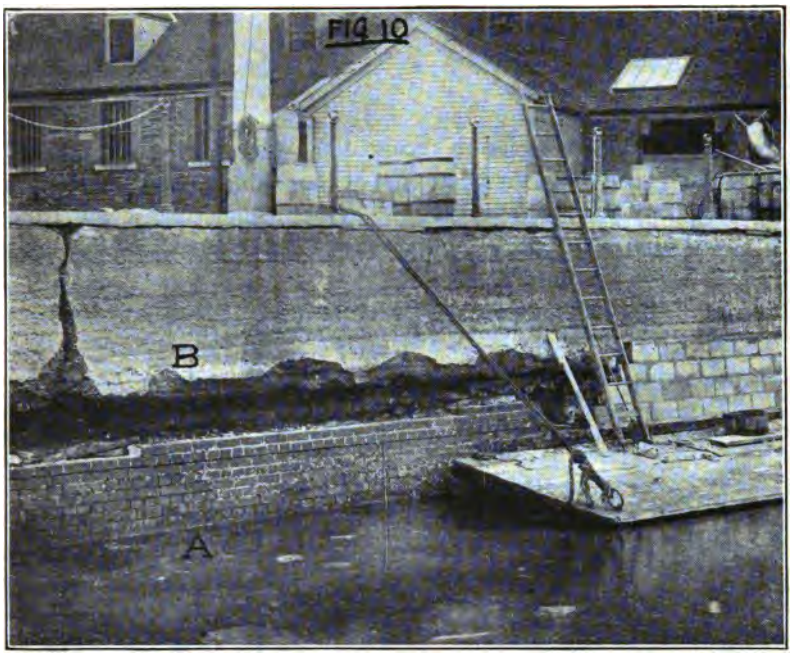
Fig. 1 is a top plan of two tile blocks, placed end to end, and kept in line by grooves and tongues at D. B B are holes in the ends and sides of the blocks to allow the wet concrete to flow into the blocks by gravity. Concrete can also be put in directly from the top. C C are the tie-rods which prevent the blocks from spreading by the pressure of the wet concrete. The rear and end walls, and the continuous concrete connections in both directions, lock the blocks into the concrete body so that there is no possibility of separation. It is known that cement adheres very strongly to a tile surface, no matter how smooth it may be.

Figs. 2, 3, 4, 5 and 6 show the details of the blocks, and also the closing pieces which are to be used when walls are built with battered ends. The blocks can be made of any desired dimensions, but they are usually 8 in. x 8 in. x 16 in. The walls of the blocks can be made of any desired thickness, but two inches for the front and middle wall and one inch for the back and end wall is sufficient. A thoroughly vitrified and salt-glazed block, which has been subjected to a furnace heat of 2400 deg. F., is as impervious to water as a china teacup, and is not affected by sea-water, alkali, acids or gases, and, being impervious to water it cannot possibly be affected by frost or alternate wetting or drying.

After careful examination of many concrete structures in sea-water, the



Vitrified Salt-Glazed Hollow Tile Block Protection for New Concrete Structures Exposed to Freezing and Thawing between Tide Marks.



Concrete Damaged by Freezing and Thawing between Tide Marks.

committee report of The American Railway Bridge and Building Association of 1907 draws attention to the unsuitability of concrete for use between high and low tide. Many other authorities have reported numerous cases of damage in similar situations, and leading construction engineers are now either using granite or covering the concrete with wood.

Many concrete bridge piers on the railways and highways along the shores of the Bay of Fundy are entirely encased in wood, while some of the more important highway bridge piers over large rivers in fresh water, are today being built either wholly or partially of granite, much of it transported long distances, although sandstone quarries exist in the vicinity. A large concrete pile wharf for ocean steamers now under construction has a part of the concrete piles covered with wood. On the Atlantic coast, a large ocean terminal to cost several million dollars is designed with granite facing. Even on the Pacific coast, where very extensive ocean terminals are designed, concrete is barred in the intertidal space.

The cost of the vitrified tile blocks is a mere fraction of the cost of any concrete structure, and, for the exposed face, is very much cheaper than granite. No person can successfully dispute the indestructibility of vitrified tile.

Note: This Association received the title—American Railway Bridge and Building Association—at the 18th annual convention at Washington, D. C., October, 1908. Prior to that time it was called —Association of Railway Superintendents of Bridges and Buildings.

LIST OF ANNUAL CONVENTIONS.

No.	Place.	Date.	Membership.
1	St. Louis, Mo.,	Sept. 25, 1891.	60
2	Cincinnati, Ohio,	Oct. 18-19, 1892.	112
3	Philadelphia, Pa.,	Oct. 17-19, 1893	128
4	Kansas City, Mo.,	Oct. 16-18, 1894	115
5	New Orleans, La.,	Oct. 15-16, 1895	122
6	Chicago, Ill.,	Oct. 20-22, 1896	140
7	Denver, Col.,	Oct. 19-21, 1897	127
8	Richmond, Va.,	Oct. 18-19, 1898	148
9	Detroit, Mich.,	Oct. 17-18, 1899	148
10	St. Louis, Mo.,	Oct. 16-18, 1900	143
11	Atlanta, Ga.,	Oct. 15-17, 1901	171
12	Minneapolis, Minn.,	Oct. 21-23, 1902	195
13	Quebec, Canada,	Oct. 20-22, 1903	223
14	Chicago, Ill.,	Oct. 18-20, 1904	293
15	Pittsburg, Pa.,	Oct. 17-19, 1905	313
16	Boston, Mass.,	Oct. 16-18, 1906	340
17	Milwaukee, Wis.,	Oct. 15-17, 1907	341
18	Washington, D. C.,	Oct. 20-22, 1908	368
19	Jacksonville, Fla.,	Oct. 19-21, 1909	393
20	Denver, Colo.,	Oct. 18-20, 1910	428
21	St. Louis, Mo.,	Oct. 17-19, 1911	499
22	Baltimore, Md.,	Oct. 15-17, 1912	524
23	Montreal, Que.,	Oct. 21-23, 1913	570

	1891-2.	1892-3.	1893-4.	1894-5.
President	O. J. Travis...	H. M. Hall.....	J. E. Wallace....	Geo. W. Andrews
1st. V.-Pres. .	H. M. Hall.....	J. E. Wallace...	Geo. W. Andrews..	W. A. McGonagle.
2nd. V.-Pres.	J. B. Mitchell..	G. W. Hinman.	W. A. McGonagle.	L. K. Spafford.
3rd. V.-Pres.	James Stannard.	N. W. Thompson	L. K. Spafford....	James Stannard.
4th. V.-Pres. .	G. W. Hinman..	C. E. Fuller...	E. D. Hines.....	Walter G. Berg.
Secretary	C. W. Gooch...	S. F. Patterson.	S. F. Patterson....	S. F. Patterson.
Treasurer	George M. Reid	George M. Reid.	George M. Reid..	George M. Reid.
Executive Members .	W. R. Damon..	G. W. Andrews.	Q. McNab	James Stannard.
	G. W. Markley.	J. M. Staten...	A. S. Markley....	James H. Travis.
	W. A. McGonagle	J. M. Caldwell..	Floyd Ingram.....	J. H. Cummin.
	G. W. McGehee.	Q. McNab.....	James Stannard ..	R. M. Peck.
	G. W. Turner...	Floyd Ingram...	James H. Travis ..	J. L. White.
	J. E. Wallace...	A. S. Markley..	J. H. Cummin	A. Shane.

	1895-6.	1896-7.	1897-8.	1898-9.
President	W. A. McGonagle	James Stannard.	Walter G. Berg....	J. H. Cummin.
1st. V.-Pres. .	L. K. Spafford	Walter G. Berg.	J. H. Cummin....	A. S. Markley.
2nd. V.-Pres.	James Stannard.	J. H. Cummin...	A. S. Markley....	C. C. Mallard.
3rd. V.-Pres.	Walter G. Berg.	A. S. Markley..	G. W. Hinman....	W. A. Rogers.
4th. V.-Pres. .	J. H. Cummin.	R. M. Peck...	C. C. Mallard.....	J. M. Staten.
Secretary	S. F. Patterson.	S. F. Patterson..	S. F. Patterson....	S. F. Patterson.
Treasurer	George M. Reid.	N. W. Thompson	N. W. Thompson..	N. W. Thompson.
Executive Members .	R. M. Peck....	W. O. Eggleston	G. J. Bishop.....	Wm. S. Danes.
	J. L. White...	W. M. Noon...	C. P. Austin.....	J. H. Markley.
	A. Shane	J. M. Staten...	M. Riney	W. O. Eggleston.
	A. S. Markley..	G. J. Bishop....	Wm. S. Danes....	R. L. Heflin.
	W. M. Noon...	C. P. Austin....	J. H. Markley....	F. W. Tanner.
	J. M. Staten...	M. Riney	W. O. Eggleston..	A. Zimmerman.

	1899-1900.	1900-1901.	1901-1902.	1902-1903.
President	Aaron S. Markley	W. A. Rogers...	W. S. Danes.....	B. F. Pickering.
1st. V.-Pres. .	W. A. Rogers...	W. S. Danes....	B. F. Pickering..	C. C. Mallard.
2nd. V.-Pres.	J. M. Staten....	B. F. Pickering.	A. Shane	A. Shane.
3rd. V.-Pres.	Wm. S. Danes...	A. Shane.....	A. Zimmerman ..	A. Zimmerman.
4th. V.-Pres. .	B. F. Pickering..	A. Zimmerman .	C. C. Mallard....	A. Montzheimer.
Secretary	S. F. Patterson..	S. F. Patterson.	S. F. Patterson,.	S. F. Patterson.
Treasurer	N. W. Thompson	N. W. Thompson	N. W. Thompson.	N. W. Thompson
Executive Members .	T. M. Strain....	T. M. Strain....	A. Montzheimer..	W. E. Smith.
	R. L. Heflin....	H. D. Cleaveland.	W. E. Smith.....	A. W. Merrick.
	F. W. Tanner...	F. W. Tanner...	A. W. Merrick...	C. P. Austin.
	A. Zimmerman...	A. Montzheimer.	C. P. Austin.....	C. A. Lichty.
	H. D. Cleaveland	W. E. Smith....	C. A. Lichty.....	W. O. Eggleston.
	A. Montzheimer.	A. W. Merrick..	W. O. Eggleston.	J. H. Markley.

	1903-1904.	1904-1905.	1905-1906.	1906-1907.
President	A. Montzheimer..	C. A. Lichty...	J. B. Sheldon....	J. H. Markley.
1st. V.-Pres. .	A. Shane	J. B. Sheldon..	J. H. Markley....	R. H. Reid.
2nd. V.-Pres.	C. A. Lichty....	J. H. Markley..	R. H. Reid.....	J. P. Canty.
3rd. V.-Pres.	J. B. Sheldon...	R. H. Reid.....	R. C. Sattley....	H. Rettinghouse.
4th. V.-Pres. .	J. H. Markley...	R. C. Sattley...	J. P. Canty.....	F. E. Schall.
Secretary	S. F. Patterson..	S. F. Patterson..	S. F. Patterson..	S. F. Patterson.
Treasurer	C. P. Austin....	C. P. Austin....	C. P. Austin.....	C. P. Austin.
Executive Members .	R. H. Reid.....	W. O. Eggleston	H. Rettinghouse .	W. O. Eggleston
	W. O. Eggleston	A. E. Killam....	A. E. Killam.....	A. E. Killam.
	A. E. Killam....	H. Rettinghouse.	J. S. Lemond.....	J. S. Lemond.
	R. C. Sattley....	J. S. Lemond...	C. W. Richey....	C. W. Richey.
	H. Rettinghouse..	W. H. Finley..	H. H. Eggleston.	H. H. Eggleston
	J. S. Lemond....	C. W. Richey...	F. E. Schall.....	B. J. Sweatt.

	1907-1908.	1908-1909.	1909-1910.	1910-1911.
President	R. H. Reid.....	J. P. Canty	J. S. Lemond...	H. Rettinghouse
1st. V.-Pres. .	J. P. Canty.....	H. Rettinghouse..	H. Rettinghouse..	F. E. Schall
and. V.-Pres.	H. Rettinghouse..	F. E. Schall.....	F. E. Schall.....	A. E. Killam
3rd. V.-Pres.	F. E. Schall	J. S. Lemond....	A. E. Killam...	J. N. Penwell
4th. V.-Pres. .	W. O. Eggleston.	A. E. Killam....	J. N. Penwell..	L. D. Hadwen .
Secretary	S. F. Patterson..	S. F. Patterson..	C. A. Lichty....	C. A. Lichty
Treasurer	C. P. Austin....	C. P. Austin....	J. P. Canty.....	J. P. Canty
Executive Members .	A. E. Killam....	J. N. Penwell....	W. Beahan	T. J. Fullem
	J. S Lemond.....	Willard Beahan ..	F. B. Scheetz .	G. Aldrich
	C. W. Richey....	F. B. Scheetz...	L. D. Hadwen ..	P. Swenson
	T. S. Leake.....	W. H. Finley...	T. J. Fullem....	G. W. Rear
	W. H. Finley....	L. D. Hadwen ..	G. Aldrich.....	W. O. Eggleston.
	J. N. Penwell....	T. J. Fullem....	P. Swenson.....	W. F. Steffens

	1911-1912.	1912-1913.	1913-1914.	
President	F. E. Schall	A. E. Killam....	J. N. Penwell .	
1st. V.-Pres. .	A. E. Killam ...	J. N. Penwell...	L. D. Hadwen	
2nd. V.-Pres.	J. N. Penwell ...	L. D. Hadwen...	G. Aldrich	
3rd. V.-Pres.	L. D. Hadwen ..	T. J. Fullem....	G. W. Rear ...	
4th. V.-Pres. .	T. J. Fullem	G. Aldrich	C. E. Smith ...	
Secretary	C. A. Lichty	C. A. Lichty.....	C. A. Lichty ..	
Treasurer	J. P. Canty	J. P. Canty.....	J. P. Canty ...	
Executive Members .	G. Aldrich	G. W. Rear....	W. F. Steffens	
	P. Swenson	W. F. Steffens...	E. B. Ashby ..	
	G. W. Rear	E. B. Ashby....	S. C. Tanner .	
	W. F. Steffens ..	C. E. Smith....	Lee Jutton ...	
	E. B. Ashby	S. C. Tanner....	W. F. Strouse .	
	W. O. Eggleston	Lee Jutton	C. R. Knowles	

CONSTITUTION

ARTICLE I.

NAME.

SECTION 1. This association shall be known as the American Railway Bridge & Building Association.

ARTICLE II.

OBJECT.

SECTION 1. The object of this association shall be the advancement of knowledge pertaining to the principles, design, construction and maintenance of railway bridges, buildings and other structures, by investigation, reports and discussion of the experience of its members and others, and to provide a means of exchange of ideas, so that bridge and building practice may be systematized and improved.

SECT. 2. The association shall neither endorse nor recommend any particular patents, materials or supplies, but individual opinions of members may be expressed and appear in the proceedings.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The membership of this association shall consist of two classes, active and life members.

SECT. 2. A person who is actively engaged in railway service in a responsible position, in charge of work connected with the construction or maintenance of railway bridges and buildings or other structures, or a professor of engineering, government timber expert, or railroad architect shall be eligible for active membership upon application to the secretary, and the payment of three dollars membership fee, and two dollars for one year's dues.

SECT. 3. Any member elected a life member of this association shall have all the privileges of an active member, but shall not be required to pay annual dues. To be elected a life member he must have been a member of the association at least five years and before being elected must have been pensioned by the railway company for which he worked or shall have retired from active railway service.

SECT. 4. Any member guilty of dishonorable conduct, or conduct unbecoming a railroad official and member of this association, or who shall refuse to obey the chairman, or rules, may be expelled by a two-thirds vote of the members present.

SECT. 5. Membership shall continue until written resignation is received by the secretary, unless member has been previously expelled.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of this association shall be a president, four vice-presidents, a secretary, a treasurer, and six executive members.

SECT. 2. The executive members, together with the president, vice-presidents, secretary and treasurer, shall constitute the executive committee.

SECT. 3. Past presidents of this association who continue to be members shall be entitled to be present at all meetings of the executive committee, of which meetings they shall receive due notice, and be permitted to discuss all questions and to aid said committee by their advice and counsel; but said past-presidents shall not have a right to vote, nor shall their presence be requisite in order to constitute a quorum.

SECT. 4. Vacancies in any office for the unexpired term shall be filled by the executive committee without unnecessary delay.

ARTICLE V.

EXECUTIVE COMMITTEE.

SECTION 1. The executive committee shall exercise a general supervision over the financial interests of the association, assess the amount of annual and other dues, call, prepare for and conduct general or special meetings, make all necessary purchases and contracts required to conduct the general business of the association, but shall not have the power to render the association liable for any debt beyond the amount then in the treasurer's hands not subject to other prior liabilities. All appropriations for special purposes must be acted upon at a regular meeting of the association.

SECT. 2. Two thirds of the members of the executive committee may call special meetings, thirty days' notice being given members by mail.

SECT. 3. Five members of the executive committee shall constitute a quorum for the transaction of business.

ARTICLE VI.

ELECTION OF OFFICERS AND TENURE OF OFFICE.

SECTION 1. The officers, excepting as otherwise provided, shall be elected at the regular meeting of the association, held on the third Tuesday in October of each year, and the election shall not be postponed except by unanimous consent.

SECT. 2. The president and treasurer shall be elected by ballot by a majority of votes cast, and shall hold office for one year or until successors are elected. No member in arrears shall be eligible for office, and the president shall not be eligible for re-election.

Vice-Presidents and Executive Members.

SECT. 3. The vice-presidents shall hold office for one year and executive members for two years; four vice-presidents and three executive members to be elected each year; all officers herein named to hold office until successors are chosen.

SECT. 4. In the election of vice-presidents, each one shall be elected by a majority vote. Executive members shall be elected in the same way, all voting to be by written ballots.

Secretary.

SECT. 5. A secretary shall be elected by a majority of the votes of the members present at the annual meeting. The term of office of the secretary shall be for one year, unless terminated sooner by action of the executive committee, two thirds of whom may remove the secretary at any time. His compensation shall be fixed by a majority of the executive committee. The secretary shall also be secretary of the executive committee.

Treasurer.

SECT. 6. The treasurer shall be required to give bond in an amount to be fixed by the majority of the executive committee.

ARTICLE VII.

COMMITTEES.

Nominating Committee.

SECTION 1. After each annual meeting the president shall appoint a committee of five members, not officers of the association, of whom two at least shall be past presidents, and two of whom shall have served on the committee the previous year. They shall prepare a list of names of nominees for officers to be voted on at the next annual convention, agreeable to Article VI. of this constitution, said list to be read at the first session of the second day of said convention. Nothing in this section shall be construed to prevent any member making nominations.

Auditing Committee.

SECT. 2. At the first session of each annual meeting there shall be appointed by the president an auditing committee of three members, not officers of the association, whose duty it shall be to examine the accounts and vouchers of the secretary and treasurer and certify as to the correctness of their accounts. Acceptance of this committee's report will be regarded as the discharge of the committee.

Committee on Subjects for Discussion.

SECT. 3. At the annual meeting there shall be appointed, by the president, a committee, whose duty it shall be to prepare and report subjects for investigation and discussion at the next annual meeting. It shall be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall decide whether such questions are suitable ones for discussion, and if approved, report them to the association.

Committees on Investigation.

SECT. 4. When the committee on subjects has reported and the association approved of the same, the president shall appoint special committees to investigate and report on said subjects and he may appoint a special committee to investigate and report on any subject of which a majority of members present may approve.

Publication Committee.

SECT. 5. After each annual meeting the executive committee shall appoint a publication committee of three active members

whose duty it shall be to supervise the publication of the proceedings. The assignment of this committee shall be such that at least one member shall have served on the committee during the previous year. The publication committee will report to the president and perform their duties under his supervision.

ARTICLE VIII.

ANNUAL DUES.

SECTION 1. Every active member shall pay to the secretary three dollars membership fee and shall also pay two dollars per year in advance to defray the necessary expenses of the association. No member being one year in arrears for dues shall be entitled to vote at any election, and any member one year in arrears may be stricken from the list of members at the discretion of the executive committee.

ARTICLE IX.

AMENDMENTS.

SECTION 1. This constitution may be amended at any regular meeting by a two thirds vote of members present, provided that a written notice of the proposed amendment, or amendments, has been given at least sixty days previous to said regular meeting.

BY-LAWS

TIME OF MEETING.

1. The regular meeting of this association shall be held annually on the third Tuesday in October.

HOUR OF MEETING.

2. The regular hour of meeting shall be at 10 o'clock a. m., unless changed by order of the presiding officer.

PLACE OF MEETING.

3. The cities or places for holding the annual convention may be proposed at any regular meeting of the association before the final adjournment. The places proposed shall be submitted to a ballot vote of the members of the association, the city or place receiving a majority of all the votes cast to be declared the place of the next annual meeting; but if no place received a majority of all votes, then the place receiving the lowest number of votes shall be dropped on each subsequent ballot until a place is chosen.

QUORUM

4. At the regular meeting of the association, fifteen or more members shall constitute a quorum.

ORDER OF BUSINESS.

5. 1st—Calling of roll.
2nd—Reading minutes of last meeting.
3rd—Admission of new members.
4th—President's address.
5th—Reports of secretary and treasurer.
6th—Payment of annual dues.
7th—Appointment of committees.
8th—Reports of committees.
9th—Unfinished business.
10th—New business.
11th—Reading and discussion of questions propounded by members.
12th—Miscellaneous business.
13th—Election of officers.
14th—Adjournment.
(Report of nominating committee to be read at first session of second day.)

DUTIES OF OFFICERS.

6. The president shall have general supervision of the affairs of the association. He shall preside at all meetings of the association, and of the executive committee, at which he may be present; shall appoint all committees not otherwise provided for, and shall be ex-officio member of all committees. He shall, with the secretary, sign all contracts or other written obligations of the association which have been approved by the executive committee.

At the annual meeting the president shall present a report containing a statement of the general condition of the association, and an address.

7. The vice-presidents in order of seniority shall preside at meetings in the absence of the president, and discharge his duties in case of a vacancy in his office.

8. It shall be the duty of the secretary to keep a correct record of proceedings of all meetings of this association; to keep correct all accounts between this association and its members; collect all moneys due the association, and pay the same over to the treasurer and take his receipt therefor, and to perform such other duties as the association may require.

9. The treasurer shall receive all moneys and deposit the same in the name of the association and shall receipt to the secretary therefor. He shall invest all funds not needed for current disbursements as shall be ordered by the executive committee. He shall pay all bills, when properly certified and approved by the president, and make such reports as may be called for by the executive committee.

DECISIONS.

10. The votes of a majority of members present shall decide any question, motion or resolution which shall be brought before the association, unless otherwise provided.

DISCUSSIONS.

11. All discussions shall be governed by Robert's rules of order.

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Walther, C. H., Supvr. B. & B., Mo. Pac. Ry., Poplar Bluff, Mo.
Warcup, C. F., For. W. S., G. T. R., St. Thomas, Ont.
Ware, B. C., Mast. Carp., C. R. I. & P. Ry., Dalhart, Tex.
Ware, Norton, C. E., Forum Bldg., Sacramento, Cal.
Warne, C. C., Purch. Dept., N. Y. C. & H. R. R., New York City.
Watson, P. N., Supvr. B. and B., Maine Central R. R., Brunswick, Me.
Wehlen, Charles, Br. Inspr., L. I. R. R., Jamaica, N. Y.
Weise, F. E., Chief Clerk, Eng. Dept., C. M. & St. P. Ry., Chicago.
Weldon, A., For. B. & B., Sou. Pac. Co., Los Angeles, Cal.
Welker, G. W., Supvr. B. and B., Southern Ry., Alexandria, Va.
Wells, A. A., R. M. and Supvr. B. & B., Sou. Ry., Winston-Salem, N. C.
Wells, D. T., For. B. and B., O. S. L. R. R., Salt Lake City, Utah.
Wells, L. N., Div. For., B. & M. R. R., Concord, N. H.
Wenner, E. R., Supvr. B. and B., L. V. R. R., Ashley, Pa.
Wester, C. A., Div. Engr., Sou. Pac. Co., Dunsmuir, Cal.
Wheaton, L. H., Div. Engr., G. T. P. Ry., Dartmouth, N. S.
White, George W., Asst. Engr., Sou. Ry., Charlotte, N. C.
White, I. F., Div. Engr., C. H. & D. Ry., Dayton, O.
White, J. B., For. W. S., C. & N. W. Ry., Boone, Ia.
Whiting, B. F., Supvr. B. & B., M. & O. R. R., Murphysboro, Ill.
Whitney, W. C., Supvr. B and B., B. & A. R. R., Boston, Mass.
Wicks, Warren, Gen'l For. L. I. R. R., Amityville, N. Y.
Wiley, J. G., Supvr. B. and B., Sou. Pac. Co., Dunsmuir, Cal.
Wilkinson, J. M., For. B. and B., C. N. R. R., Van Wert, Ohio.
Wilkinson, W. H., Bridge Insp., Erie R. R., Elmira, N. Y.
Williams, Arthur, Engr., W. & M. Ry., Wellington, N. Z.
Williams, J. C., Supvr. B. and B., A. & W. P. Ry., Opelika, Ala.
Williams, M. R., Gen. For. B. & B., A. T. & S. F. Ry., Las Vegas, N. M.
Wilson, E. E., Supvr. of Bridges, N. Y. C. & H. R. R. R., New York City, (81 E. 125th St.).
Wilson, J., Supvr. B. & B., G. T. Ry., Hamilton, Ont.
Wilson, M. M. Div. Br. Inspr., Sou. Pac. Co., Los Angeles
Wilson, W. W., Div. Engr., G. C. & S. F. Ry., Galveston, Tex.

Winter, J. L., Mast. Carp., S. A. L. Ry., Waldo, Fla.
Wise, E. F., 207 Clay St., Waterloo, Iowa.
Witt, C. C., Dist. Engr., I. C. C., 1020 McGee St., Kansas City, Mo.
Wolf, A. A., Dist. Carp., C. M. & St. P. Ry., Milwaukee, Wis.
Wood, J. P., Supvr. B. & B., P. M. R. R., Saginaw, Mich.
Wood, J. W., Gen'l For. B. and B., A. T. & S. F. Ry., Needles, Cal.
Wood, W. E., Dist. Engr., C. M. & St. P. Ry., Chicago.
Wright, C. W., Mast. Carp., L. I. R. R., Jamaica, N. Y.
Wright, G. A., Ill. Traction System, Decatur, Ill.

Yappen, Adolph, Dist. Carp., C. M. & St. P. Ry., Chicago.
Yereance, W. B., Cons. Engr., 128 Broadway, New York City.
Young, R. C., Chief Engr., L. S. & I. Ry., Marquette, Mich.

Zinck, K J. C., Ch. Engr., Alberta Int. Ry., Calgary, Alta.
Zinsmeister, E. C., Mast. Carp., B. & O. R. R., Zanesville, O.
Zook, D. C., Mast. Carp., Pa. Lines W. of Pitts., Ft. Wayne, Ind.

LIFE MEMBERS.

Austin, C. P., 107 Park St., Medford, Mass.
Carmichael, Wm., St. J. & G. I. R. R., St. Joseph, Mo.
Carpenter, J. T., Sou. Ry., Princeton, Ind.
Cummin, Jos. H., Bay Shore, N. Y.
Findley, A., 929 Wash. Ave., Portland, Me.
Forbes, Jno., 45 Victoria Road, Halifax, N. S.
Foreman, John, P. & R. Ry., Pottstown, Pa.
Gooch, C. W., 1325 W. 9th St., Des Moines, Ia.
Green, E. H. R., Texas Midland R. R., Terrell, Tex.
Hubbard, A. B., B. & M. R. R., Boston, Mass.
Lydston, W. A., Swampscott, Mass.
McIntyre, James, Miami, Fla.
McLean, Neil, Mast. Carp., Erie R. R., Huntington, Ind.
Mountain, G. A., Ch. Engr., Ry. Com. of Canada, Ottawa, Ont.
Noon W. M., 800 Ave. B., Miami, Fla.
Parks, Jas., U. P. R. R., Denver, Colo.
Patterson, S. F. (Sec. Emeritus), Concord, N. H.
Porter, L. H., Box 35, Andover, Conn.
Snow, J. P., 1120 Kimball Bldg., Boston, Mass.
Stannard, Jas., 1602 Broadway, Kansas City, Mo.
Tanner, Frank, Mo. Pac. Ry., St. Louis, Mo.
Travis, O. J., Pinehurst, Wash.
Vandegrift, C. W., C. & O. Ry., Alderson, W. Va.
Wise, E. F., 207 Clay St., Waterloo, Ia.

DECEASED MEMBERS.

Amos, A.,
Berg, Walter G.
Bishop, Geo. J.
Blair, J. A.
Brady, James.
Carr, Charles.
Causey, T. A.
Cleaveland, H. D.
Costolo, J. A.
Crane, Henry
DeMars, James.
Dunlap, H.
Fletcher, H. W.
Fuller, C. E.
Gilbert, J. D.
Gilchrist, E. M.
Graham, T. B.
Hall, H. M.
Heflin, R. L.
Henson, H. M.
Hinman, G. W.
Humphreys, Thos.
Isadell, L. S.
Johnson, J. E.
Keen, Wm. H.
Lantry, J. F.
Large, C. M.
Larson, G.
Lovett, J. W.
Markley, Abel S.
McCormack, J. W.
McGehee, G. W.
Mellor, W. J.
Millner, S. S.
Mitchell, J. B.
Mitchell, W. B.
Morgan, T. H.
Morrill, H. P.
Peck, R. M.
Perry, W. W.
Phillips, W. H.
Powell, W. T.
Reid, G. M.
Renton, Wm.
Reynolds, E. F.
Robertson, Daniel
Schaffer, J.
Schwartz, J. C.
Spafford, L. K.
Spangler, J. A.
Spaulding, E. C.
Spencer, C. F.
Taylor, J. W.
Thompson, N. W.
Tozzer, Wm. S.
Trautman, J. J.
Van Der Hoek, J.
Wallace, I. E.
Walden, W. D.
Welch, E. T.
Wells, J. M.
Wood, W. B.
Worden, C. G.

MEMBERSHIP AND MILEAGE OF RAILWAYS REPRESENTED.

Name of Road and Membership.	Members.	Mileage.
Alberta Interurban Ry.,	2	10
V. A. Newhall, Calgary, Alta.		
K. J. C. Zinck, Calgary, Alta.		
Algoma Central & Hudson Bay Ry.	1	232
R. S. McCormick, Sault Ste. Marie, Ont.		
Arizona Eastern R. R.	1	355
C. C. Mallard, Globe, Ariz.		
Atchison, Topeka & Santa Fé Ry.	4	5,963
A. J. James, Topeka, Kans.		
E. McCann, Wellington, Kans.		
John L. Talbott, Pueblo, Colo.		
M. R. Williams, Las Vegas, N. M.		
Atchison, Topeka & Santa Fé Ry. (Coast Lines)	5	2,022
E. E. Ball, Winslow, Ariz.		
J. F. Parker, San Bernardino, Cal.		
V. C. Proctor, Winslow, Ariz.		
D. A. Shope, Fresno, Cal.		
J. W. Wood, Needles, Cal.		
Atlanta & West Point R. R. and W. Ry. of Ala.	2	225
O. T. Nelson, Montgomery, Ala.		
J. C. Williams, Opelika, Ala.		
Atlantic Coast Line R. R.	1	4,500
J. W. Salisbury, Port Tampa, Fla.		
Baltimore & Ohio R. R. (System)	22	4,738
G. W. Andrews, Baltimore, Md.		
S. H. Blowers, Columbus, O.		
W. S. Bouton, Baltimore, Md.		
Z. T. Brantner, Martinsburg, W. Va.		
H. R. Bricker, Baltimore, Md.		
W. M. Clark, Pittsburgh, Pa.		
W. R. Edwards, Baltimore, Md.		
R. Henderson, Garrett, Ind.		
W. T. Hopke, Grafton, W. Va.		
E. G. Lane, Baltimore, Md.		
M. A. Long, Baltimore, Md.		
B. S. Mace, Baltimore, Md.		
J. T. McIlwain, Akron, O.		
E. G. Moore, Grafton, W. Va.		
J. O. Potts, Baltimore, Md.		
W. S. Schenck, Connellsville, Pa.		

Name of Road and Membership.	Members.	Mileage
Baltimore & Ohio R. R. (System). Continued. W. F. Strouse, Baltimore, Md. S. C. Tanner, Baltimore, Md. D. B. Taylor, Garrett, Ind. F. A. Taylor, Cumberland, Md. T. E. Thomas, Wilmington, Del. E. C. Zinsmeister, Zanesville, O.		
Bangor & Aroostook R. R.	2	628
W. E. Alexander, Houlton, Me. M. Burpee, Houlton, Me.		
Bessemer & Lake Erie R. R.	1	210
H. H. Harman, Greenville, Pa.		
Boston & Albany R. R.	1	392
W. C. Whitney, Boston, Mass.		
Boston & Maine R. R.	14	2,288
Cyrus P. Austin, Medford, Mass. J. P. Canty, Fitchburg, Mass. John Ewart, Boston, Mass. Andrew B. Hubbard, Boston, Mass. F. J. Leavitt, Salem, Mass. William A. Lydston, Swampscott, Mass. John Marsh, Lawrence, Mass. Albert Mountfort, Nashua, N. H. A. A. Page, Concord, N. H. S. F. Patterson, Concord, N. H. B. F. Pickering, Salem, Mass. Fred C. Rand, Boston, Mass. F. A. Sherwin, St. Johnsbury, Vt. L. N. Wells, Concord, N. H.		
Brazil Ry.	1	10,000
A. M. Dodd, Sao Paulo, Brazil, S. A.		
Buenos Aires & Pacific R. R.	1	3,240
Wm. McIntosh, Buenos Aires, S. A.		
Canadian Pacific Ry.	2	11,641
Frank Lee, Winnipeg, Man. D. A. McRae, Cranbrook, B. C.		
Carolina & Northwestern Ry.	1	133
J. W. Fletcher, Jr., Chester, S. C.		
Central of Georgia Ry.	1	1,916
H. C. McKee, Macon, Ga.		
Central Vermont Ry.	7	536
G. M. Cota, St. Albans, Vt. C. Donaldson, Waterbury, Vt. C. F. Flint, St. Albans, Vt. H. E. Holmes, New London, Conn. C. R. Lyman, Waterbury, Vt. C. H. Schoolcraft, Farnham, Que. W. A. Stewart, Stafford, Conn.		
Chesapeake & Ohio Ry.	6	2,041
F. M. Griffith, Covington, Ky. Oscar L. Grover, Richmond, Va.		

Name of Road and Membership.	Members.	Mileage
Chesapeake & Ohio Ry. Continued.		
C. E. Powell, Hinton, W. Va.		
J. M. Staten, Richmond, Va.		
W. F. Steffens, Richmond, Va.		
C. W. Vandegrift, Alderson, W. Va.		
Chicago & Alton R. R.	1	1,025
C. A. Stelle, Bloomington, Ill.		
Chicago & Eastern Illinois R. R.	1	1,266
A. S. Markley, Danville, Ill.		
Chicago & North Western Ry.	31	8,101
L. J. Anderson, Escanaba, Mich.		
H. Bender, Eagle Grove, Ia.		
W. A. Brewer, Chicago, Ill.		
F. L. Burrell, Fremont, Neb.		
F. M. Case, Belle Plaine, Ia.		
O. F. Dalstrom, Chicago, Ill.		
H. H. Decker, Chicago, Ill.		
T. H. Durfee, Huron, S. D.		
W. H. Finley, Chicago, Ill.		
M. J. Flynn, Chicago, Ill.		
G. W. Hand, Chicago, Ill.		
C. Herrig, Wall Lake, Ia.		
John Hunciker, Chicago, Ill.		
Lee Jutton, Madison, Wis.		
C. F. King, Omaha, Neb.		
C. A. Lichty, Chicago, Ill.		
J. A. Lorch, Chicago, Ill.		
George Loughnane, Escanaba, Mich.		
C. A. Marcy, Chicago, Ill.		
J. Mellgren, Eagle Grove, Ia.		
W. F. Meyers, Belle Plaine, Ia.		
J. W. Miller, Chicago, Ill.		
J. A. S. Redfield, Fond du Lac, Wis.		
R. W. Richardson, Sioux City, Ia.		
M. Riney, Baraboo, Wis.		
J. S. Robinson, Chicago, Ill.		
D. Rounseville, Antigo, Wis.		
Wm. Spencer, Norfolk, Nebr.		
W. M. Sweeney, Green Bay, Wis.		
O. E. Ullery, Sioux City, Ia.		
J. B. White, Boone, Ia.		
Chicago, Burlington & Quincy R. R.,	5	9,129
W. E. Elder, Burlington, Ia.		
Geo. Fenney, McCook, Neb.		
W. Hurst, St. Joseph, Mo.		
W. T. Krausch, Chicago, Ill.		
C. J. Scribner, Chicago.		
Chicago Great Western R. R.	4	1,496
W. L. Derr, Clarion, Ia.		
W. O. Eggleston, Des Moines, Ia.		
H. A. Elwell, Clarion, Ia.		
M. G. Manning, Ft. Dodge, Ia.		
Chicago, Indianapolis & Louisville Ry.	1	578
J. M. Caldwell, Lafayette, Ind.		

Name of Road and Membership.	Members.	Mileage
Chicago, Milwaukee & St. Paul Ry.	14	9,585
E. J. Auge, Wells, Minn.		
E. E. Clothier, Malden, Wash.		
H. R. Drum, Mitchell, S. D.		
L. D. Hadwen, Chicago, Ill.		
F. E. King, Minneapolis, Minn.		
N. H. LaFountain, Chicago, Ill.		
C. F. Loweth, Chicago, Ill.		
E. S. Meloy, Chicago.		
Edw. Murray, Miles City, Mont.		
William Ross, Milbank, S. D.		
Fred E. Weise, Chicago, Ill.		
William E. Wood, Chicago, Ill.		
A. A. Wolf, Milwaukee, Wis.		
A. Yappen, Chicago, Ill.		
Chicago, Rock Island & Pacific Ry.	12	7,551
S. T. Corey, Chicago, Ill.		
McClellan Bishop, El Reno, Okla.		
C. H. Eggers, Little Rock, Ark.		
E. R. Floren, Rock Island, Ill.		
Guy Gordon, Little Rock, Ark.		
M. E. Gumphrey, Eldon, Mo.		
W. V. Parker, Amarillo, Tex.		
R. C. Sattley, Chicago.		
I. L. Simmons, Chicago, Ill.		
A. M. Van Auken, Shawnee, Okla.		
R. Wagner, Little Rock, Ark.		
B. C. Ware, Dalhart, Tex.		
Chicago, St. Paul, Minneapolis & Omaha Ry.	4	1,748
J. D. Moen, Boone, Ia.		
A. G. Rask, Spooner, Wis.		
H. Rettinghouse, St. Paul, Minn.		
Aug. Ruge, Mankato, Minn.		
Chicago, Terre Haute & Southeastern Ry.	2	351
J. Dupree, Crete, Ill.		
J. O. Jewell, Terre Haute, Ind.		
Cincinnati, Hamilton & Dayton Ry.	1	1,015
I. F. White, Dayton, O.		
Cincinnati, New Orleans & Texas Pacific Ry.	1	338
F. J. Conn, Lexington, Ky.		
Cincinnati Northern R. R.	1	236
J. M. Wilkinson, Van Wert, O.		
Colorado & Southern Ry.	4	1,250
R. W. Beeson, Trinidad, Colo.		
C. W. Fellows, Denver, Colo.		
Harry James, Denver, Colo.		
A. W. Pauba, Denver, Colo.		
Colorado Midland Ry.	1	338
J. Guretzky, Colorado City, Colo.		

Name of Road and Membership.	Members.	Mileage
Columbia, Newberry & Laurens R. R.	1	75
A. P. Rice, Columbia, S. C.		
Concho, San Saba & Llano Valley R. R.	1	61
K. S. Hull, Temple, Tex.		
Copper Range R. R.	1	150
A. Giesing, Houghton, Mich.		
Delaware, Lackawanna & Western R. R., ...	7	985
F. J. Arnold, Scranton, Pa.		
G. E. Boyd, Buffalo, N. Y.		
E. Cahill, Binghamton, N. Y.		
C. G. Connolly, Scranton, N. Y.		
A. McQueen, Binghamton, N. Y.		
J. E. Ranney, Buffalo, N. Y.		
Jas. Skeoch, Dunmore, Pa.		
Denver & Rio Grande R. R.	6	2,598
G. W. Kinney, Salt Lake City.		
A. Ridgway, Denver, Colo.		
A. C. Snyder, Salt Lake City.		
H. Taylor, Alamosa, Colo.		
C. S. Thompson, Denver, Colo.		
Jas. Vaughan, Salida, Colo.		
Duluth & Iron Range R. R.	2	197
W. A. Clark, Duluth, Minn.		
B. T. McIver, Two Harbors, Minn.		
Duluth, Missabe & Northern Ry.	1	356
W. A. McGonagle, Duluth, Minn.		
Elgin, Joliet & Eastern Ry.	3	770
G. H. Jennings, Joliet, Ill.		
A. Montzheimer, Joliet, Ill.		
C. Thompson, Joliet, Ill.		
Erie R. R. (and Chicago & Erie)	7	2,665
O. F. Barnes, Susquehanna, Pa.		
W. O. Eggleston, Huntington, Ind.		
A. J. Horth, Meadville, Pa.		
F. A. Knapp, Jersey City, N. J.		
W. H. Matthews, Hornell, N. Y.		
Neil McLean, Huntington, Ind.		
W. H. Wilkinson, Elmira, N. Y.		
Florida East Coast Ry.	1	708
E. K. Barrett, St. Augustine, Fla.		
Fort Smith & Western R. R.	1	217
B. F. Beckman, Ft. Smith, Ark.		
Fort Worth & Denver City Ry.	1	454
J. M. Mann, Ft. Worth, Tex.		
Georgia & Florida Ry.	1	325
W. A. Swallow, Augusta, Ga.		
Grand Rapids & Indiana Ry.	2	592
W. S. McKeel, Grand Rapids, Mich.		
H. M. Large, Ft. Wayne, Ind.		

Name of Road and Membership.	Members.	Mileage
Grand Trunk Ry. System	16	4,756
W. Cayley, Stratford, Ont.		
J. B. Gaut, Montreal, Que.		
J. C. Gokey, Richmond, Que.		
J. Henderson, St. Thomas, Ont.		
J. H. Johnston, Montreal, Que.		
A. Larsen, Montreal, Que.		
G. C. McCue, Ottawa, Ont.		
J. McMahon, Bellville, Ont.		
George A. Mitchell, Toronto, Ont.		
H. B. Stuart, Montreal, Que.		
H. C. Swartz, St. Thomas, Ont.		
W. H. Tichbourne, London, Ont.		
J. E. Travis, Toronto, Ont.		
W. J. Tyers, Ottawa, Ont.		
C. F. Warcup, St. Thomas, Ont.		
J. Wilson, Hamilton, Ont.		
Grand Trunk Pacific Ry.	1	3,627
L. H. Wheaton, Dartmouth, N. S.		
Great Northern R. R.,	1	7,748
J. A. Bohland, St. Paul, Minn.		
Gulf, Colorado and Santa Fé Ry.	4	1,603
E. C. George, Beaumont, Tex.		
K. S. Hull, Temple, Tex.		
W. G. Massenburg, Beaumont, Tex.		
W. W. Wilson, Galveston, Tex.		
Hampshire Southern R. R.	1	38
W. Trapnell, Romney, W. Va.		
Illinois Central R. R.	13	4,755
P. Aagaard, Chicago, Ill.		
F. O. Draper, Chicago, Ill.		
C. Ettinger, Chicago, Ill.		
T. J. Fullem, Chicago, Ill.		
C. R. Knowles, Chicago, Ill.		
R. J. McKee, Freeport, Ill.		
Samuel P. Munson, Mattoon, Ill.		
W. L. Ratliff, McComb, Miss.		
William Reed, Grenada, Miss.		
M. A. Smith, New Orleans, La.		
O. M. Suter, Chicago, Ill.		
F. L. Thompson, Chicago, Ill.		
E. F. Wise (retired), Waterloo, Ia.		
Illinois Traction System	1	420
G. A. Wright, Decatur, Ill.		
Indianapolis, Columbus & Southern Traction Co.	1	62
A. Shane, Columbus, Ind.		
Intercolonial Ry.	6	1,468
T. C. Burpee, Moncton, N. B.		
Hugh Jardine, Moncton, N. B.		
H. J. McGrath, Moncton, N. B.		
W. B. MacKenzie, Moncton, N. B.		
Thomas Sefton, Moncton, N. B.		
A. C. Selig, Moncton, N. B.		

Name of Road and Membership.	Members.	Mileage
International & Great Northern Ry.	1	1,106
H. M. Jack, Palestine, Tex.		
Kansas City, Clinton & Springfield Ry.	1	155
J. B. Browne, Clinton, Mo.		
Kansas City Southern Ry.	2	762
C. E. Johnston, Kansas City, Mo.		
J. J. Taylor, Texarkana, Tex.		
Lake Erie & Western R. R.	3	882
T. O. Andrews, Tipton, Ind.		
P. P. Lawrence, Tipton, Ind.		
J. N. Penwell, Tipton, Ind.		
Lake Shore & Michigan Southern Ry.	4	1,863
Willard Beahan, Cleveland, O.		
Philip O'Neill, Adrian, Mich.		
R. H. Reid, Cleveland, O.		
J. L. Soisson, Norwalk, O.		
Lake Superior & Ishpeming Ry., Munising Ry., and Marquette & S. E. Ry.	2	160
August Anderson, Marquette, Mich		
Roscoe C. Young, Marquette, Mich.		
Lehigh & Hudson River Railway	1	96
J. E. Barrett, Warwick, N. Y.		
Lehigh & New England R. R.	1	269
W. E. Harwig, Bethlehem, Pa.		
Lehigh Valley R. R.	10	1,453
E. B. Ashby, New York City.		
Peter Hofecker, Auburn, N. Y.		
J. W. Holcomb, Buffalo, N. Y.		
Judson Joslin, Auburn, N. Y.		
David A. Keefe, Athens, Pa.		
A. E. Kemp, Hazleton, Pa.		
A. L. Reynolds, New York City.		
F. E. Schall, South Bethlehem, Pa.		
L. W. Swan, Easton, Pa.		
E. R. Wenner, Ashley, Pa.		
Long Island R. R.	4	392
W. F. O'Connor, Flushing, N. Y.		
Chas. Wehlen, Jamaica, N. Y.		
W. Wicks, Amityville, N. Y.		
C. W. Wright, Jamaica, N. Y.		
Louisiana & Arkansas Ry.	1	255
W. H. Vance, Stamps, Ark.		
Louisville & Nashville R. R. (and Nash. Term. Co.)	11	4,923
J. M. Bibb, Birmingham, Ala.		
A. J. Catchot, Ocean Springs, Miss.		
R. O. Elliott, Nashville, Tenn.		
H. R. Hill, Birmingham, Ala.		
Floyd Ingram, Erin, Tenn.		
J. W. Little, Birmingham, Ala.		

Name of Road and Membership.	Members.	Mileage
Louisville & Nashville R. R. Continued. A. B. McVay, Evansville, Ind. C. M. Roy, Birmingham, Ala. Wm. Sheley, Evansville, Ind. H. Stamler, Paris, Ky. W. G. Stewart, Nashville, Tenn.		
Maine Central R. R. P. N. Watson, Brunswick, Me.	1	1,206
Michigan Central R. R. S. D. Bailey, Detroit, Mich. Thomas Hall, St. Thomas, Ont. Henry A. Horning, Jackson, Mich.	3	1,817
Minneapolis & St. Louis R. R. Ed. Gagnon, Minneapolis, Minn. G. S. Kibbey, Minneapolis, Minn.	2	1,586
Minneapolis, St. Paul & Sault Ste. Marie Ry. P. Swenson, Minneapolis, Minn. G. A. Manthey, Minneapolis, Minn.	2	4,020
Miss. River & Bonne Terre Ry. C. H. Fake, Bonne Terre, Mo.	1	64
Missouri, Kansas & Texas Ry. A. S. Clopton, Parsons, Kans.	1	3,073
Missouri Pacific Ry. System (including St. Louis, Iron Mountain & Southern Ry.) E. E. Allard, St. Louis, Mo. Robert J. Bruce, St. Louis, Mo. W. L. Burnett, Eudora, Ark. L. J. Byrd, Dermott, Ark. H. R. DeWitt, Little Rock, Ark. A. H. Ferdina, St. Louis, Mo. C. Gnadt, Poplar Bluff, Mo. E. H. Harvey, Montrose, Ark. Lon Graves, Dermott, Ark. W. Hausgen, Sedalia, Mo. E. P. Hawkins, Bastrop, La. W. J. Lacy, Poplar Bluff, Mo. C. W. Lamb, Pine Bluff, Ark. G. W. Land, McGehee, Ark. C. E. Redmond, Van Buren, Ark. J. V. Reynolds, Dermott, Ark. D. L. Roper, Monroe, La. C. E. Smith, St. Louis, Mo. E. A. Stanley, St. Louis, Mo. Wm. Sullivan, Kansas City, Mo. F. W. Tanner, St. Louis, Mo. L. J. Wackerle, Osawatomie, Kans. A. L. Waits, St. Louis, Mo. C. H. Walther, Poplar Bluff, Mo.	24	7,284
Mobile & Ohio R. R. W. B. Harris, Murphysboro, Ill. B. F. Whiting, Murphysboro, Ill.	2	1,114

Name of Road and Membership.	Members.	Mileage
Nashville, Chattanooga & St. Louis Ry.	1	1,230
I. O. Walker, Paducah, Ky.		
National Rys. of Mexico	1	6,177
Hans Bentele, Mexico City, Mex.		
New South Wales Government Rys.	1	3,472
James Fraser, Sydney, N. S. W.		
New York Central & Hudson River R. R.	12	2,829
J. K. Bonner, Rochester, N. Y.		
U. S. Hitesman, New York City.		
G. J. Klumpp, Rochester, N. Y.		
R. P. Mills, New York City.		
Kemper Peabody, N. Y. City.		
W. A. Pettis, Rochester, N. Y.		
E. J. Rykenboer, Rochester, N. Y.		
S. A. Seely, Watertown, N. Y.		
E. R. Tattershall, Malone, N. Y.		
H. C. Thompson, Weehawken, N. J.		
C. C. Warne, New York City.		
E. E. Wilson, New York City.		
New York, New Haven & Hartford R. R.	10	2,091
Grosvenor Aldrich, Boston, Mass.		
J. S. Browne, Providence, R. I.		
H. H. Kinzie, Taunton, Mass.		
Wm. H. Moore, New Haven, Conn.		
B. P. Phillips, Willimantic, Conn.		
L. H. Porter (retired), Andover, Conn.		
George A. Rodman, New Haven, Conn.		
George T. Sampson, Boston, Mass.		
D. W. Sharpe, New Haven, Conn.		
J. B. Sheldon, Providence, R. I.		
New York, Ontario & Western R. R.	1	494
J. H. Nuelle, Middletown, N. Y.		
New Zealand Government Rys.	2	2,717
C. H. Biss, Christchurch, N. Z.		
George A. Troup, Wellington, New Zealand.		
Northern Pacific Ry.	5	6,313
James Hartley, Staples, Minn.		
F. Ingalls, Jamestown, N. D.		
C. S. McCully, Jamestown, N. D.		
R. E. McFarlane, Duluth, Minn.		
J. C. Taylor, Glendive, Mont.		
North Western Govt. Rys. (India)	1	4,431
D. M. Cookson, Kalaw, Burma, India.		
Northwestern Pacific R. R.	1	469
A. A. Robertson, San Rafael, Cal.		
Oregon Short Line R. R.	15	2,022
Robt. Barr, Pocatello, Idaho.		
J. F. Cullen, Pocatello, Idaho.		
W. C. Dale, Pocatello, Idaho.		
J. S. Eastman, Idaho Falls, Idaho.		
O. Forsgren, Brigham, Utah.		

Name of Road and Membership.	Members.	Mileage
Oregon Short Line R. R. Continued. C. J. Harris, Roberts, Idaho. A. H. King, Salt Lake City, Utah. C. T. Musgrave, Idaho Falls, Idaho. R. Newton, Pocatello, Idaho. P. E. Parsons, Salt Lake City, Utah. S. J. Powell, Ogden, Utah. A. W. Robinson, Salt Lake City, Utah. R. B. Robinson, Salt Lake City, Utah. A. R. Stevens, Salt Lake City, Utah. D. T. Wells, Salt Lake City, Utah.		
Pacific Electric Ry. D. E. Plank, Los Angeles, Cal.	1	987
Pennsylvania Lines West of Pittsburgh Samuel C. Bowers, Steubenville, O. Stanton Bowers, Bradford, O. B. F. Gehr, Richmond, Ind. A. F. Miller, Chicago, Ill. D. G. Musser, Wellsville, O. H. H. Pollock, Carnegie, Pa. J. Wallenfelsz, Cambridge, O. D. C. Zook, Fort Wayne, Ind.	8	3,098
Pennsylvania R. R. M. M. Barton, West Philadelphia, Pa. Richard G. Develin, Philadelphia, Pa. H. R. Leonard, Philadelphia, Pa. Robert McKibbon, Altoona, Pa. A. W. Reynolds, New York City. C. W. Richey, Pittsburgh, Pa.	6	5,304
Pere Marquette R. R. J. D. Black, Saginaw, Mich. Edw. Guild, Grand Rapids, Mich. G. E. Hanks, East Saginaw, Mich. A. L. McCloy, Reese, Mich. A. McNab, Holland, Mich. John Robinson, Grand Rapids, Mich. J. E. Toohey, Grand Rapids, Mich. J. P. Wood, Saginaw, Mich.	8	2,336
Philadelphia & Reading Ry. Amos H. Beard, Reading, Pa. John Foreman (retired), Pottstown, Pa. E. G. Storck, Philadelphia, Pa. E. E. Templin, Pottsville, Pa.	4	1,481
Pittsburgh & Lake Erie R. R. D. L. McKee, McKee's Rocks, Pa. G. H. Soles, Pittsburgh, Pa.	2	215
Queen & Crescent Route E. L. Loftin, Vicksburg, Miss.	1	509
Quincy, Omaha & Kansas City R. R. T. F. DeCapito, Milan, Mo.	1	261
San Antonio & Aransas Pass Ry. J. D. Lacy, Morgan City, La.	1	724

Name of Road and Membership	Members.	Mileage
San Pedro, Los Angeles & Salt Lake R. R.	4	1,075
F. M. Bigelow, Salt Lake City, Utah.		
R. R. Bishop, Salt Lake City, Utah.		
W. C. Frazier, Los Angeles, Cal.		
D. W. Scannell, Salt Lake City, Utah.		
Seaboard Air Line Ry.	8	3,046
W. M. Barker, Scotia, S. C.		
B. B. Christy, Tallahassee, Fla.		
W. J. Gooding, Jr., Jacksonville, Fla.		
B. Land, Jr., Tampa, Fla.		
W. A. McDearmid, Tallahassee, Fla.		
J. C. Nelson, Portsmouth, Va.		
G. B. Smith, Jacksonville, Fla.		
J. L. Winter, Waldo, Fla.		
St. Joseph & Grand Island Ry.	2	319
O. H. Andrews, St. Joseph, Mo.		
Wm. Carmichael, St. Joseph, Mo.		
St. Louis & San Francisco R. R.	1	4,740
F. G. Jonah, St. Louis, Mo.		
St. Louis Southwestern Ry.	2	1,451
J. S. Berry, St. Louis, Mo.		
Wm. Quinn, Tyler, Tex.		
Southern Ry.	15	7,036
D. A. Ballenger, Greenville, S. C.		
J. H. Blackwell, Charleston, S. C.		
R. E. Connor, Columbia, S. C.		
H. S. Douglass, Charleston, S. C.		
W. F. Fraylick, Charleston, S. C.		
J. R. Fowlkes, Columbia, S. C.		
N. L. Hall, Greensboro, N. C.		
Joseph A. Killian, Jr., Charlotte, N. C.		
J. S. Lemond, Charlotte, N. C.		
J. W. Morgan, Columbia, S. C.		
C. A. Redinger, Knoxville, Tenn.		
T. E. Sharpe, Greenville, S. C.		
J. B. Teaford, Louisville, Ky.		
G. W. Welker, Alexandria, Va.		
A. A. Wells, Winston-Salem, N. C.		
G. W. White, Charlotte, N. C.		
Southern New England Ry.	1	85
J. E. Cole, Providence, R. I.		
Southern Pacific Company	57	6,453
C. J. Astrue, Portland, Ore.		
T. W. Bratten, West Oakland, Cal.		
H. Bulger, Oakland Pier, Cal.		
W. H. Burgess, Stockton, Cal.		
D. Burke, Tucson, Ariz.		
F. L. Burkhalter, Portland, Ore.		
W E. Burns, Portland, Ore.		
J. T. Caldwell, Bakersfield, Cal.		
W. S. Corbin, Los Angeles, Cal.		

Name of Road and Membership.	Members	Mileage
Southern Pacific Company. Continued.		
G. S. Crites, Tucson, Ariz.		
D. M. Crosman, Los Angles, Cal.		
Geo. Dickson, Oakland, Cal.		
R. M. Drake, San Francisco, Cal.		
J. A. Draper, Portland, Ore.		
B. F. Ferris, Los Angeles, Cal.		
J. F. Fisher, Sacramento, Cal.		
M. Fisher, Ogden, Utah.		
A. Fraser, Bakersfield, Cal.		
Neil Fraser, San Francisco, Cal.		
P. Fritz, Los Angeles, Cal.		
W. Gaskin, Los Angeles, Cal.		
Ira Gentis, Oakland, Cal.		
J. A. Givens, Sacramento, Cal.		
Jas. Gratto, Los Angeles, Cal.		
C. F. Green, Sacramento, Cal.		
P. Guisto, San Francisco, Cal.		
W. C. Harmon, Bakersfield, Cal.		
J. Hubley, Colfax, Cal.		
C. A. Jensen, Los Angeles, Cal.		
H. Lodge, San Francisco, Cal.		
J. B. Malloy, San Francisco, Cal.		
J. D. Mathews, Tucson, Ariz.		
F. D. Mattos, W. Oakland, Cal.		
M. J. Mayer, San Francisco, Cal.		
C. W. McCandless, Ventura, Cal.		
W. H. McCoy, Dunsmuir, Cal.		
D. McGee, Sacramento, Cal.		
A. M. McLeod, Oakland, Cal.		
E. C. Morrison, San Francisco, Cal.		
J. J. Murphy, Oakland, Cal.		
P. N. Nelson, San Francisco, Cal.		
Harry Pollard, San Francisco, Cal.		
Homer Pollard, West Oakland, Cal.		
Geo. W. Rear, San Francisco, Cal.		
J. S. Replogle, Oakland, Cal.		
D. T. Rintoul, Bakersfield, Cal.		
A. L. Robinson, Stockton, Cal.		
Norman Rose, Portland, Ore.		
W. M. Rose, Sacramento, Cal.		
Niles Searls, San Francisco, Cal.		
F. M. Siefer, Portland, Ore.		
C. W. Smith, Portland, Ore.		
E. J. Vincent, Los Angeles, Cal.		
C. A. Webster, Dunsmuir, Cal.		
A. Weldon, Bakersfield, Cal.		
J. G. Wiley, Dunsmuir, Cal.		
M. M. Wilson, Los Angeles, Cal.		
Tennessee Central R. R.	1	393
E. M. Carter, Nashville, Tenn.		
Texas & Pacific Ry.	1	1,883
E. Loughery, Marshall, Tex.		
Texas Midland R. R.	1	125
E. H. R. Green, Terrell, Tex.		

Name of Road and Membership.	Members.	Mileage.
Thousand Islands Ry.	1	18
H. A. Cooper, Gananoque, Ont.		
Toledo, Peoria & Western Ry.	1	248
J. H. Markley, Peoria, Ill.		
Toledo Railways & Light Co.,	1	110
A. Swartz, Toledo, O.		
Trinity & Brazos Valley Ry.	1	466
B. M. Hudson, Teague, Tex.		
Union Pacific R. R.,	1	3,574
J. Parks, Denver, Colo.		
Virginian Ry.,	1	444
P. W. Cahill, Roanoke, Va.		
Wabash R. R.	2	2,514
A. O. Cunningham, St. Louis, Mo.		
William S. Danes, Peru, Ind.		
Washington Terminal Co.	2	53
W. M. Cardwell, Washington, D. C.		
C. H. Spencer, Washington, D. C.		
Wellington & Manawata Ry. (New Zealand)	1	84
Arthur Williams, Wellington, New Zealand.		
Western Australia Government Rys.	1	1,943
E. S. Hume, Midland Jct., Western Australia.		
Western Pacific Ry.	2	934
M. R. Krutsinger, Sacramento, Cal.		
T. J. Stuart, Elko, Nev.		
Wheeling & Lake Erie R. R.	3	496
Wm. Mahan, Canton, O.		
W. L. Rohbock, Cleveland, O.		
E. U. Smith, Cleveland, O.		
Yazoo & Miss. Valley R. R.	2	1,370
D. H. Holdridge, Vicksburg, Miss.		
W. Shropshire, Greenville, Miss.		
Total Members and Mileage,	508	248,209
Members not with Railroads,	67	
Total Membership,	575	

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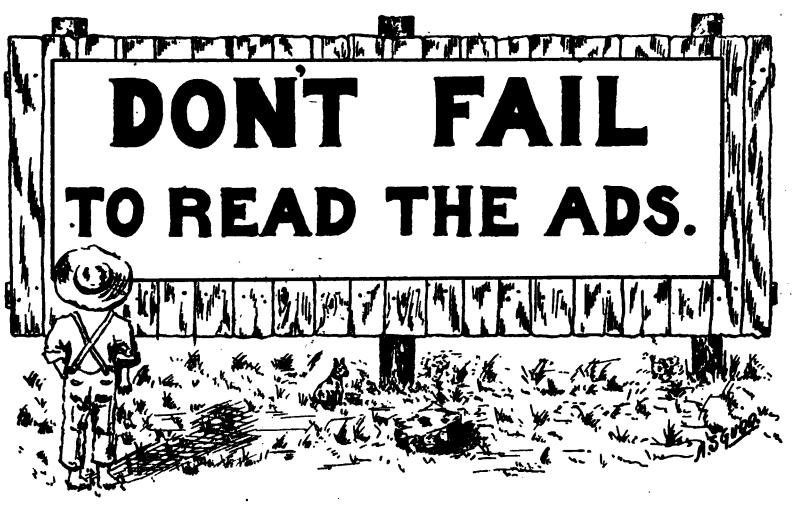

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AN investigation into net roofing costs will promptly disclose the superiority of Barrett Specification Roofs. Their first cost is lower than that of any other permanent roof, and, as they require no painting or other care for upwards of twenty years, their maintenance cost is nil.

The Bush Terminal Company, with a total roof area of more than 70 acres (3,100,000 square feet) on their 181 buildings in Brooklyn, N. Y., illustrated below, studied the subject of roofing costs and adopted this type of roofs. The Vice-President of the Bush Terminal Company writes:

> We use this kind of roofing because our experience has shown it to be the best and cheapest. Our analysis of first cost of application and cost of maintenance entitles us to speak with some measure of authority.

The roofing contractor states that the expense for maintenance of this entire roof area has been less than $10 and estimates that if metal or ready-made roofings had been used it would have been impossible to keep the buildings free from leaks, and that the painting bill alone up to date would probably have amounted to at least $50,000.

It is on such evidence as this that we base the statement that the maintenance cost of Barrett Specification Roofs is *nothing per year*—and the $10 exception "proves the rule".

A copy of The Barrett Specification free on request. Address our nearest office.

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ARE STRONGEST AND SAFEST

Compare their heavy pins and axles, the extra thick plates and straps, the smoothly ground groove in the hard iron sheave, with those of any other block made.

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automatically maintain a uniform stage of water in Standpipes, Reservoirs or Tanks. No overflow in case of fire pressure. Valves closed by water or electricity

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Automatic Valves

For Steam and Water Service

"Automatic Float Valves"

"Angle or Globe"

Valves up to 24 inches

The Golden-Anderson Float Valves

are instantly adjusted to operate Quickly or Slowly as desired. Indestructible. They are Absolutely the Only Satisfactory Float Valve Known for High or Low Pressure.

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We make the largest, heaviest and most correct mechanically constructed and operated line of Automatic Valves for high or low pressure steam and water service in the U. S.

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Golden-Anderson Pat. Automatic Standpipe Valves

¶Has no equal "For High and Low Pressure." "Cushioned in Opening and Closing"

¶Owing to their Correct Inside Mechanical Construction They Are Absolutely Guaranteed ¶This Valve can be Connected to any Standpipe, also Direct to City Mains

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"AUTOMATIC"
"Angle or Globe"

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Reducing Valves for Steam or Water

U. S. Steel Corp'n ordered over 1,193 of our valves for the protection of their "Power Stations"

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P. R. R. Co.
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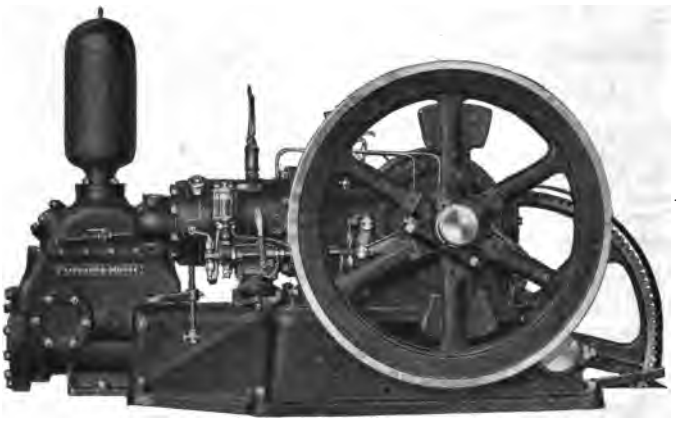

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Western Sales Agt., L. P. TOLMAN, Central Bld., Seattle, Wash.

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Water Closet Combination

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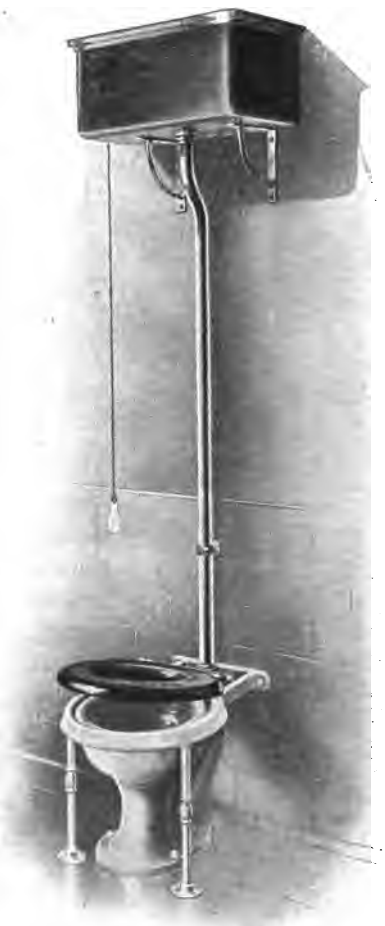

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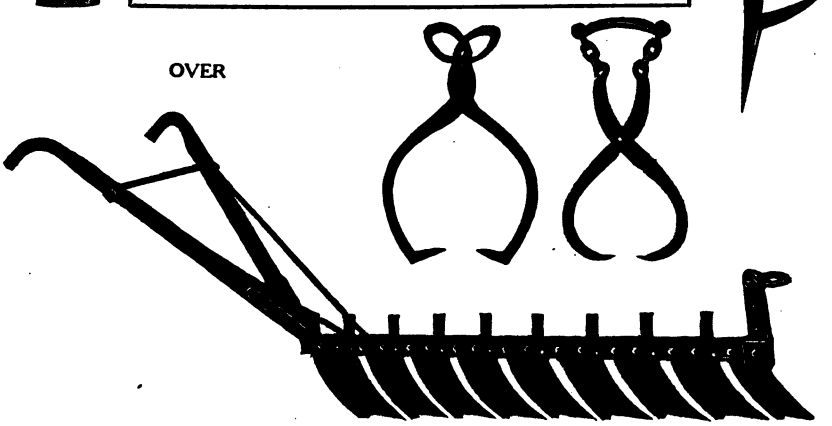

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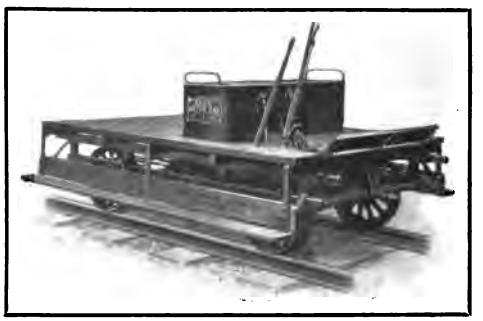

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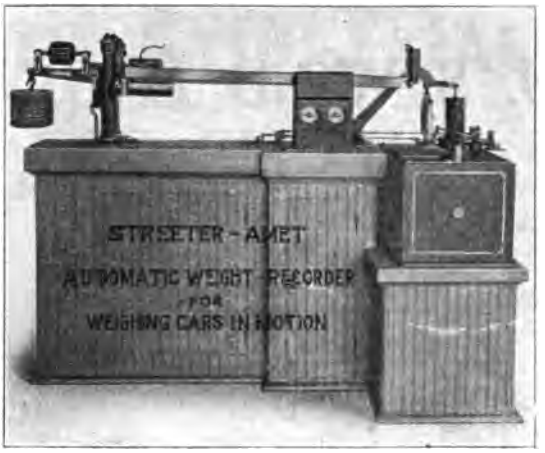
Pumping Machines of All Kinds
Semaphores and Switch Stands



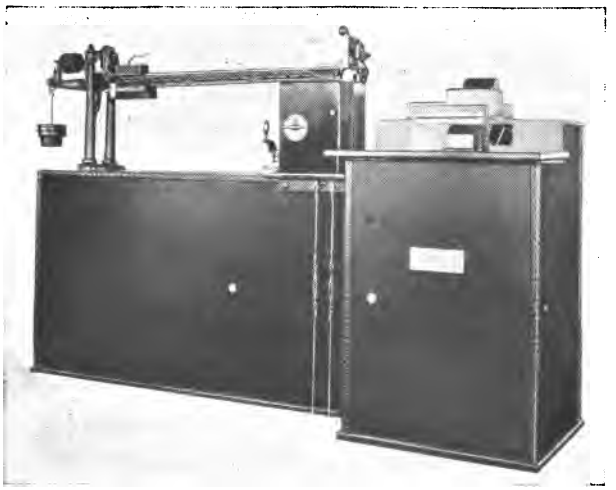
200,000 POUNDS STANDARD RECORDER

THE STREETER-AMET
Automatic Weight Recorder

For Railway Track Scales

is used by 60 leading railroads and 26 private industries. It is a standard device of 27 years standing. Bulletin 1A for the asking.

STREETER-AMET WEIGHING & RECORDING CO.
Chicago



300,000 POUNDS NEW TYPE RECORDER

ROOFINGS for RAILWAY USE

That are Fire Resisting and Impervious to the corroding action of bituminous gases

Rex Flintkote Roofing

The standard of quality for all prepared roofings. Selected after most severe tests by the Constructing Engineers as the best roof to cover the large train sheds of the Atlanta Terminal Depot, Atlanta, Ga., the Mobile Terminal Depot, Mobile, Ala., and the New Union Station, Birmingham, Ala.

Rex Flintkote Roofing invites your critical inspection. It is not what we say, but what it will do, that will interest you.

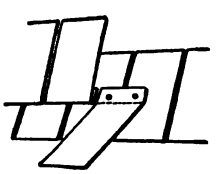
Samples and booklet on request.

Rex-Tile (Flintkote) Shingles

The Scientific Shingle

By their method of application, these shingles have absolutely solved the shingle problem.

Each shingle is eight inches by eighteen inches with a two inch turn under at the butt end for nailing. This makes it impossible for the shingle to warp, twist, curl or crack and absolutely prevents turning up or blowing up.



How to Nail

Made in two colors—red and slate. These colors are not merely a destructible mineral surface coating that easily washes and wears off—but **are an actual part of the material itself,** and remain the same indefinitely.

Absolutely waterproof and fire resisting, Rex-tile Shingles are the ideal covering for small stations, depots, etc. They give positive protection against all the destructive elements, and their everlasting colors give the necessary touch, from the standpoint of attractiveness.

This is a proposition you should not overlook.

Send for samples and literature.

FLINTKOTE MFG. CO.

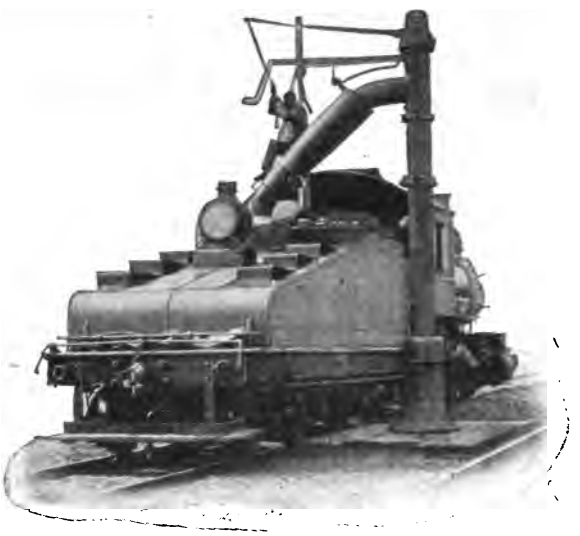
Main Offices, 88 Pearl St., Boston, Mass.

New York **Chicago** **New Orleans**

The Latest Improved

Poage Water Column

Equipped with Fenner Drop Spout



Style "H"

Water can be taken quicker. Cost for maintenance is less than any other column.

The Fenner Drop Spout has five feet vertical adjustment to reach highest and lowest tenders without wasting water.

The three feet lateral movement of the spout makes accurate spotting unnecessary. This saves time and money. The lateral movement prevents knocking the column over should locomotive shift with spout in tender.

The open telescopic joint without packing, or working parts prevents freezing during coldest weather.

Automatically shuts off the water. Spout when released returns parallel to track by gravity.

Write for All Facts

The American Valve & Meter Co.

CINCINNATI, OHIO

THE

ELLIS

Patent Bumping Posts

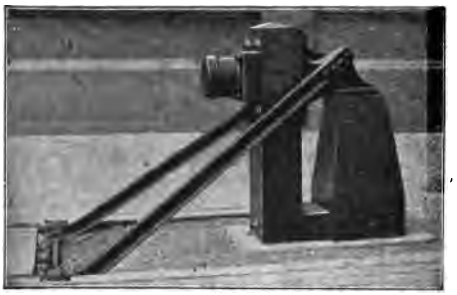
Noted for simplicity strength and lasting qualities. Neat in appearance. Occupy little space. Adapted to all positions. Highest Award at the World's Fair.

Shipped Complete With Directions for Erecting

Write for circulars and prices.

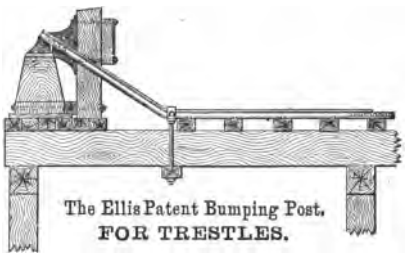
Mechanical Mfg. Co.

Chicago, Ill.



Standard Passenger Post

Standard Freight Post

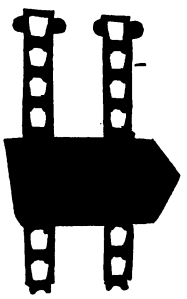


The Ellis Patent Bumping Post.
FOR TRESTLES.

A Test

ELEVATING, CONVEYING *and* POWER TRANSMITTING MACHINERY

Caldwell "HELICOID" Conveyor



ICE Handling Machinery

- Screw Conveyors
- Belt Conveyors
- Steel Elevator Legs
- Elevator Buckets
- Gears with Cut or Machine Molded Teeth
- Chain Belting
- Sprocket Wheels
- Shafting, Bearings

Ask for Catalog No. 38

CARTS CRUSHERS TROLLEY SYSTEMS

ENDLESS CHAIN CONVEYORS, ELEVATORS

Complete Equipment for icing or re-icing refrigerated traffic with least possible delay
Send for Special Ice Machinery Catalogs

H. W. CALDWELL & SON CO.

17th St. and Western Ave., Chicago

HUDSON TERMINAL, 50 CHURCH ST., NEW YORK

One Roofing Used Twice

After fighting smoke, burning cinders and storm for seven years, the roofing shown above on the old Wells Street Station of the C. & N. W. R. R. in Chicago, was rolled up and used to re-roof several suburban stations. It is

NEPONSET PAROID ROOFING

This hard wear has not taken the life out of the roofing, and it is now giving perfect service in its new locations. A good life insurance risk is the man who lives beyond the average time—longer than he is *expected* to live. A good roofing is one that lasts *longer* than is necessary. That's what NEPONSET Paroid does. An ideal roofing for factories, storehouses and farm buildings.

BIRD & SON 515 Neponset Street
E. Walpole, Mass.

New York Chicago Washington San Francisco
Canadian Plant: Hamilton, Ont.
Established 1795

NEPONSET
Proslate Roofing
makes a handsome red or green roof for houses

SIX INCHES of ASPHALT CEMENT-WELDED JOINT

Instead of the ordinary, clumsy joint, easily broken and with all nail-heads showing, you can have an absolutely tight, six-inch weld, without a nail-hole through the roof, if you use

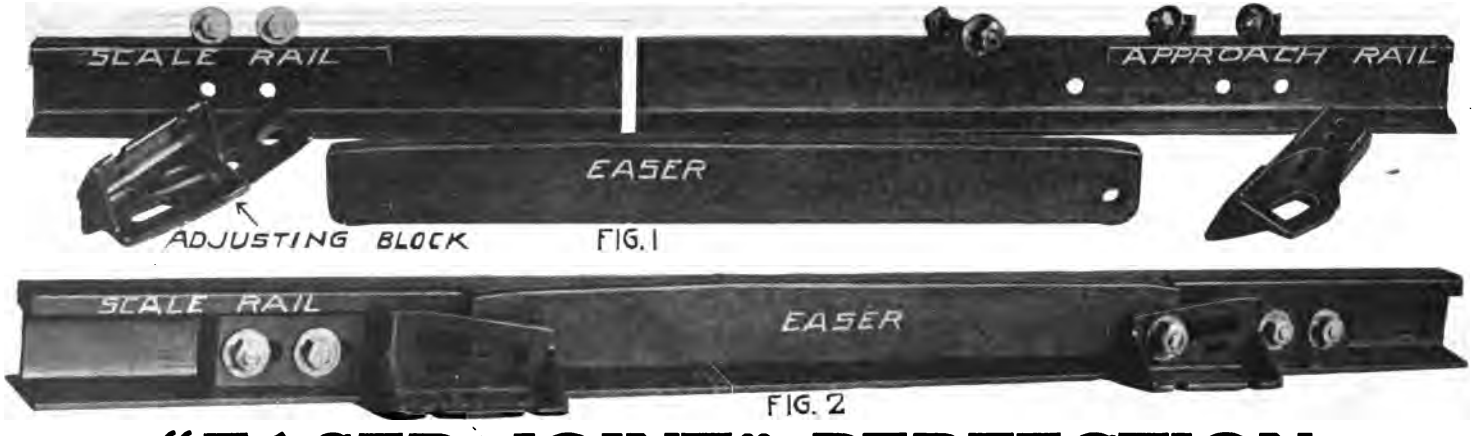
Write today for free book, "The Requirements of a GOOD Roof." It tells in detail why Security Wide-Weld Asphalt Roofing meets these requirements, and how easy it is to weld the patented 6-inch joint.

SECURITY WIDE-WELD ASPHALT ROOFING

The National Roofing Co.

Manufacturers of Asphalt Roofing and Paint

Address communications to 217 Filmore Ave. Tonawanda, N.Y.



"EASER JOINT" PERFECTION

(PATENTED)

Adjustable and Flexible

Fits All Weights and Sections of Rail

General approval is only obtained thru genuine merit. Genuine merit is only obtained thru genuine effort. Thru untiring effort we have obtained genuine merit and thereby general approval of our EASER JOINTS for TRACK SCALES. If you desire the best write us.

BOHANNAN-DUGGER COMPANY

ENSLEY **ALABAMA**

American Bridge Company of New York

Engineers and Contractors for

STRUCTURAL STEEL WORK

OF ALL DESCRIPTIONS

CONTRACTING OFFICES IN PRINCIPAL CITIES OF THE UNITED STATES

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Timber Bridges and Trestles
MADE SAFE

against fire dropped by locomotives and their life prolonged by one coat of

Clapp's
Fire Resisting Paint

An Inexpensive Money, Life and Property Saver

You need such protection
We have the goods
We will "show you"
You pay nothing down

We furnish the paint and it must do all we claim or we lose

Note our Make Good or No Pay Proposition
Could anything be Fairer?

The Clapp Fire Resisting Paint Co.
BRIDGEPORT, CONN.

J-M Waterproofing

does not dry out, chip, crack or run, because its base is pure natural asphalt—the most perfect waterproofing substance in existence. In selecting a material for waterproofing purposes, the first consideration is durability. Waterproofing that is not PERMANENTLY waterproof becomes a mere makeshift, and one that is likely to prove mighty expensive in the long run.

Guy St. Bridge, Canadian Pacific Railway
J-M Waterproofing applied

If you have a waterproofing problem to solve for new shops, bridges, buildings, platforms, subways, reservoirs, or anything else, write our nearest branch and they will gladly coöperate with you.

Our staff of Engineers has successfully executed some of the largest and most difficult waterproofing jobs. And you get the benefit of this experience and skill no matter how small your job may be.

J-M Mastic Flooring

Unlike our waterproofing products, the base of all our J-M MASTIC is genuine Trinidad Lake asphalt—that wonderful natural asphalt. It will not originate dust, a point of vital importance in railroad work.

This flooring is unequaled for freight house and platform floors, even under the heaviest trucking conditions. Being waterproof, it is absolutely sanitary as it can be quickly and thoroughly cleaned by the simple process of flushing. As it does not cause foot-soreness and fatigue like concrete and other non-yielding floor surfaces, it adds greatly to the efficiency as well as comfort of employees of machine shops, freight houses, warehouses, etc.

J-M MASTIC is the cheapest-per-year flooring.

Write for booklet 113

H. W. JOHNS-MANVILLE CO.

MANUFACTURERS OF ASBESTOS AND MAGNESIA PRODUCTS

TRADE ASBESTOS MARK

ASBESTOS ROOFINGS, PACKINGS ELECTRICAL SUPPLIES, ETC.

Akron	Cincinnati	Houghton	Newark, N. J.	St. Paul
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Birmingham	Dayton	Los Angeles	Philadelphia	Syracuse
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Steel Water Tanks

1—Have pleasing appearance, long life, low maintenance cost.

2—Will not rot, burst or burn.

3—Remain absolutely water-tight.

4—Require no wooden frost casing.

5—Need no expansion joint.

6—Are built entirely of steel.

7—Are practically self cleaning.

8—Cost about the same as wooden tanks.

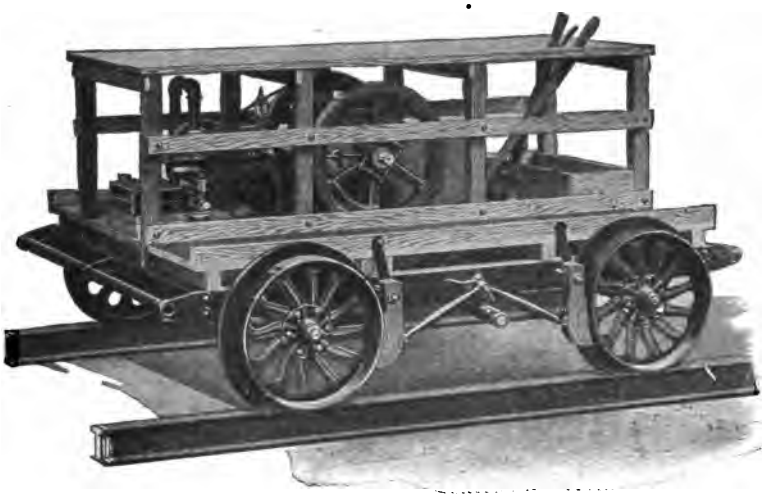
Write us for plans, specifications and prices before placing your order

CHICAGO BRIDGE & IRON WORKS

Offices: Chicago, New York, Dallas, Texas, Greenville, Pa., Bridgeburg, Ont., Can.

Chicago
Greenville, Pa.
Bridgeburg, Ont., Can.

HUSKY JERRY BOY MOTOR CAR



MEANS

QUICK transportation of men and material.

SAVING of energy for direct track work.

LOW FIRST cost—small maintenance expense.

POWERFUL four-cycle reversible engine.

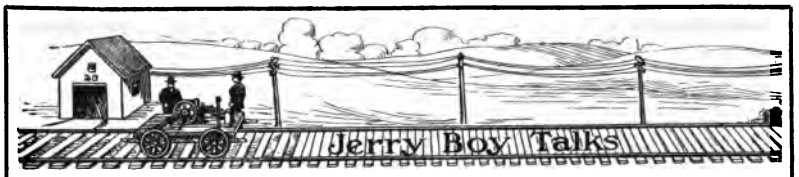
ABSOLUTE reliability at all times.

The service record of the Jerry Boy Motor Car on a hundred railroads in forty-two states and Canada challenges the most careful investigation by Bridge and Building and Maintenance of Way Officials. Ask for booklet.

Complete Outfit or Engine Alone

ASSOCIATED MANUFACTURERS CO.

WATERLOO, IOWA



HEAR WHAT
HE SAYS—

SOME LOAD.

I have had occasion to haul 73 ties on push car and three men and tools, and made a speed of 16 miles per hour. Everybody says my engine beats anything they ever saw. I cannot say too much for the Jerry Boy. Mind you, this Jerry Boy is only 2¼ horse power, but I have pulled six 33-foot 80 lb. rails, also 12 men—total 5,280 lbs. In the year I have had the engine it has traveled about 6,322 miles at a repair expense of 45c.

SAVES AN HOUR A DAY.

I have one of those Jerry Boy engines, made by the Associated Manufacturing Co., Waterloo, Iowa. The engine cost $56.00 and the freight, I am receiving the best kind of service from it, it has never been out of fix and it saves an hour's time every day if I am working five or six miles away from the tool house. I must say it is a good thing and I wish all foremen had them as they save a lot of time.

STUCK ON THE JERRY BOY.

I took my Roadmaster on an 86 mile trip one day last week and he said that he never saw an engine run so nice as my Jerry Boy. He is stuck on my car. Jerry Boy Engine ran as long as we wanted it to and was always ready to start when we were ready.

OUT AND OUT FOR JERRY BOY.

I am an out and out Jerry Boy advocate, as I have fourteen of them on my division out of a possible nineteen sections, and I think others will fill out in the spring. I have had a chance to see most all cars, and for simplicity and sure go—I prefer the Jerry Boy every time.

RIGHT ON THE JOB.

I have found the Jerry Boy engine to be very successful and the best on the road. My Roadmaster has a ———— engine and I had to push him up the hill the other day. I had a little trouble with the engine in the first tests, but now as I have learned it thoroughly there is no more trouble While this Jerry Boy engine is not supposed to make more than 15 miles per hour, it can do it with ten men and tools.

ORIGINAL LETTERS IN FILE

ASSOCIATED MANUFACTURERS CO.

WATERLOO, IOWA

HOWE·SCALE

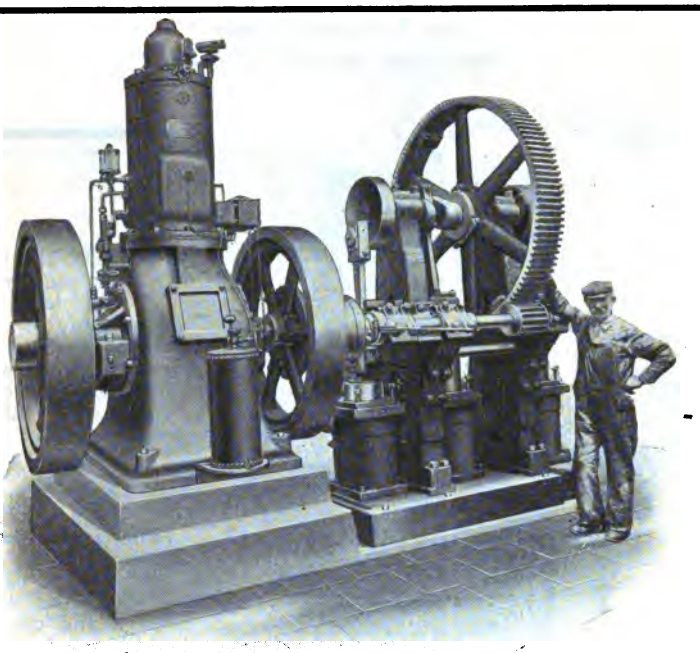
THE HOWE SCALE COMPANY factory at RUTLAND is a most complete equipped plant for the manufacture of every size scale from an 8 oz. postal balance to track scales of 200 tons capacity. Now covering 17 acres, it being continually enlarged to meet the increasing demand for HOWE scales---regardless of the number turned out each day, every scale is set up and tested before leaving the factory. ***61 years of this kind of service makes this scale the one you should use.***

HOWE SCALE CO. OF ILLINOIS

CHICAGO

St. Louis Cleveland Minneapolis Kansas City

ECONOMY WATER SUPPLY



A SERIES OF OFFICIAL TESTS on many railroads have demonstrated that a

Crescent
OIL ENGINE PUMPING UNIT

for Railway Water Supply Service at tank stations gives the most economical results. The entire cost of operation, including labor, up-keep, lubricating and fuel oil, with a plant using the Crescent Pumping Unit as per above illustration, having a capacity of one million gallons per month, pumping against 150 feet head, using an Oil of 29 degrees Beaume is One Cent per thousand gallons. This is the result of a test made after one year's steady operation. INVESTIGATE YOUR COSTS.

Samuel L. Moore & Sons Corporation

MAIN OFFICE AND WORKS: ELIZABETH, N. J., U. S. A.

Chicago Office
537 South Dearborn Street

Cable Address
Crescent, Elizabeth

COACH YARD HYDRANTS

Sizes ¾ in. and 1 in. only

(More styles shown in catalog)

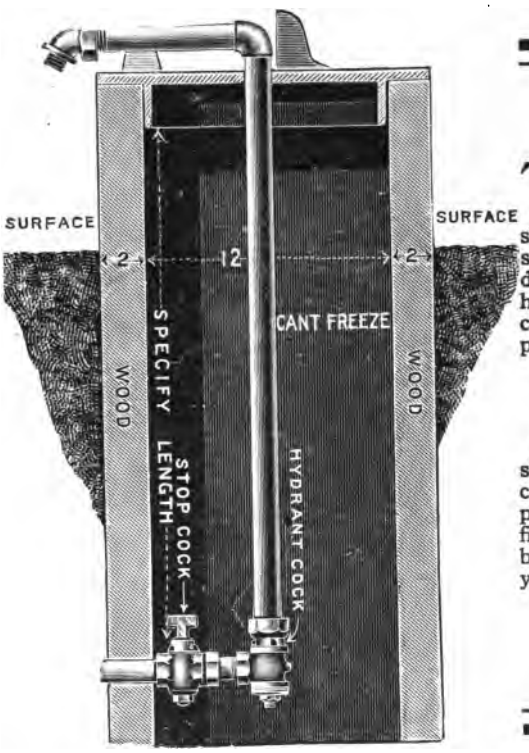


Fig. 18

THE SPACE is too limited here to show many of our small types of hydrants, you will have to get our catalog for that purpose.

The iron cover shown in Fig. 18 costs $1.00 each per set. Buy the fittings and cover, build hydrant yourself.

Fig. 10
Hydrant
Cock

Fig. 34
Union
Coupling

Fig. 38
Control
Cock

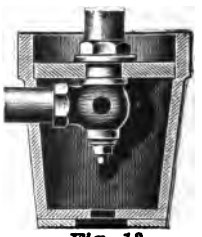


Fig. 12
Hydrant Valve

VOLKHARDT COMPANY INC.

51 Townsend Ave. **Stapleton, N. Y.**

Western Agts. Willis C. Squire & Co.
Western Union Bldg., Chicago, Ill.

ASH OR CINDER PIT HYDRANTS

Sizes, 1¼ in., 1½ in., 2 in. and 2½ in.

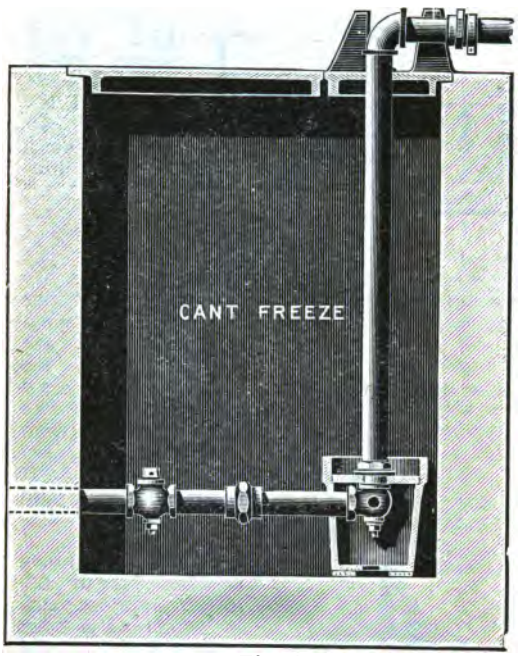


Fig. 4

THIS FIG. 4 has been adopted as "standard" by a number of roads and is always specified on all new work.

When the valve needs renewing, no digging is required. The pit will admit a full grown man, see blue print in our catalog for detailed dimensions.

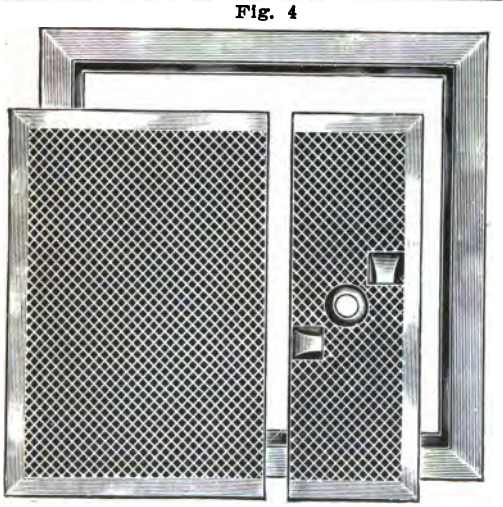


Fig. 7
Cast Iron Covers and Frame for Fig. 4 and 30.

We will sell the iron cover, Fig. 7 or the main valve, Fig. 12 separate. Make up your own hydrant.

VOLKHARDT COMPANY INC.
51 Townsend Ave.,
Stapleton, N. Y.

Western Agents
WILLIS C. SQUIRE & CO.
Western Union Building
Chicago, Ill.

STOCK (HOG) SPRINKLERS

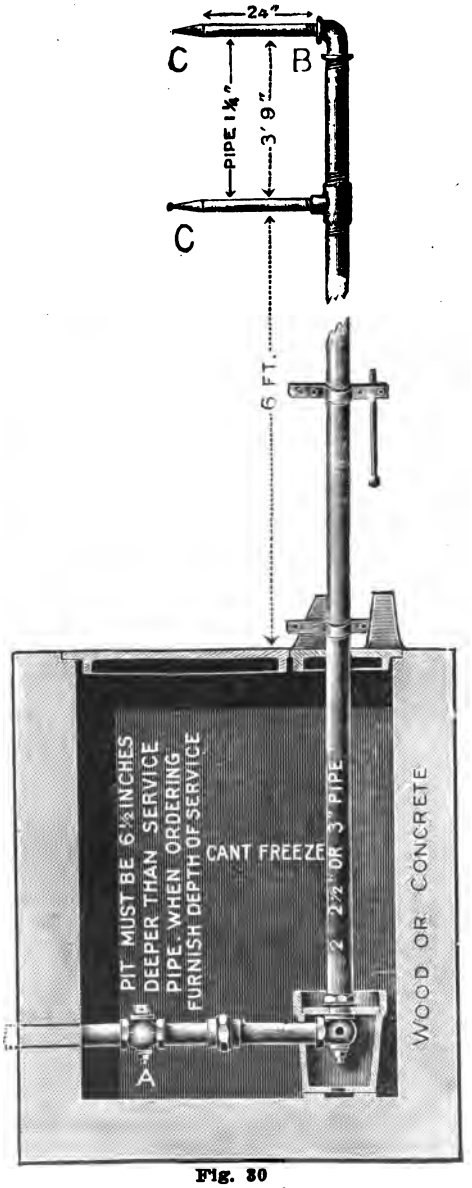


Fig. 30
For Iron Cover, See Fig. 7

THIS CUT shows another way to set up the VOLKHARDT valve. In this it serves as a sprinkler for a double deck stock car, men are not required at each stand pipe to direct the water, the arms are set at the proper height. When turned on they are swung toward the moving cars and left there until the last car passes, then swung back parallel with the tracks. It is always ready and can't freeze.

Our catalog shows another form for lower deck of car, by attaching a hose instead of rigid arms.

When the valve needs renewing, no digging is required, the pit is large enough to admit a man, see blue print in catalog for detailed dimensions.

We will gladly sell the valve, Fig. 12, separate, also the iron cover, Fig. 7. You get the balance at home, or we will furnish Fig. 30 complete.

VOLKHARDT COMPANY INC.
51 Townsend Avenue
Stapleton, N. Y.

CAN'T FREEZE FIRE LINE

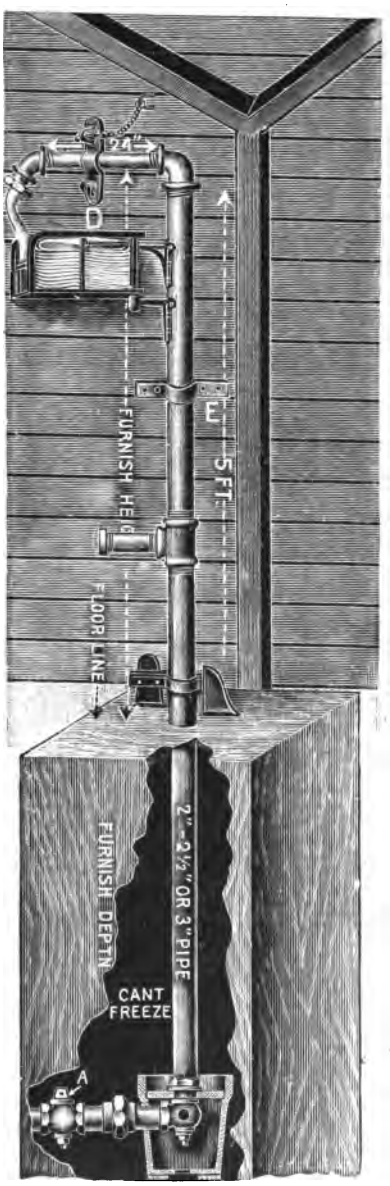


Fig. 28

THIS CUT shows one way of setting up the VOLKHARDT valve for a quick opening fire line.

Set up as this is, it becomes a "one man fire hydrant." A watchman can unreel the hose and at the same time turn on the water, no going back to open the valve, valuable time saved and the fire don't get ahead of him.

Our catalog shows another "set up." The space here is too limited to show more.

This form of fire hydrant is displacing the old types very fast for use in freight houses, outer walls of shop buildings, lumber yards and other exposed places because it can't freeze up. Try it.

We will gladly sell the valve, Fig. 12, separate. You get the rest at home.

VOLKHARDT COMPANY INC.

51 Townsend Avenue
Stapleton, N. Y.

Western Agents
WILLIS C. SQUIRE & CO.
Western Union Building
Chicago, Ill.

DICKINSON *AEOLUS*

(E - O - LUS)

Sheet Metal

and

Cast Iron

Ventilators

For all purposes requiring reliable ventilation

Write

PAUL DICKINSON, Inc.

189 W. Madison St. CHICAGO

KELLY-DERBY CO., Inc.

754 Peoples Gas Building

Chicago, Ill.

Headquarters for

Pumps
Power Heads

RAILWAY SUPPLIES CO. PEOPLES GAS BLDG. CHICAGO

Engines
Motors

Well Cylinders
Well Strainers

Generators
Steel Trucks

Feed Water Heaters and Purifiers, Hose, Belting
Packing, Diaphragms, Pump Valves
Dredging Sleeves, Cushions

ALWAYS ON THE JOB

AND MAKE GOOD

Barker Mail Crane

"SELF ADJUSTING" COIL SPRINGS, HOLD THE POUCH

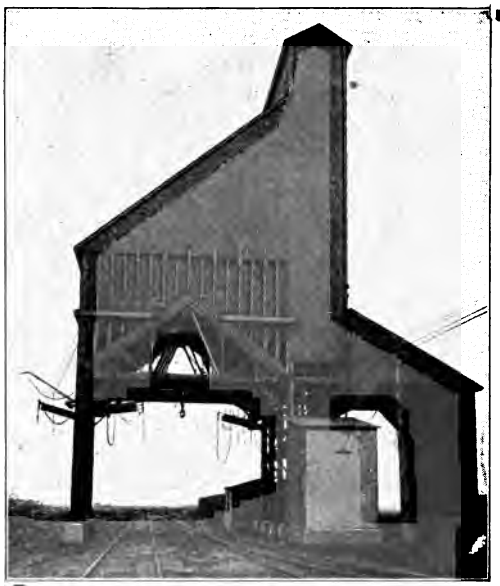
It is assembled, painted two coats, and ready to set up. Set up in two hours new, or changed in 30 minutes

Practically indestructible, the standard crane of a large number of leading roads. We are selling hundreds of them

PRICE $13.00, $5.00 cheaper than you can build and erect wooden cranes

Send For LATEST CATALOGUE

BARKER MAIL CRANE CO.
CLINTON, IOWA



Full Cycle Automatic

COALING STATIONS

Built in all sizes and capacities

Operates successfully under adverse as well as favorable conditions. Serves any number of tracks

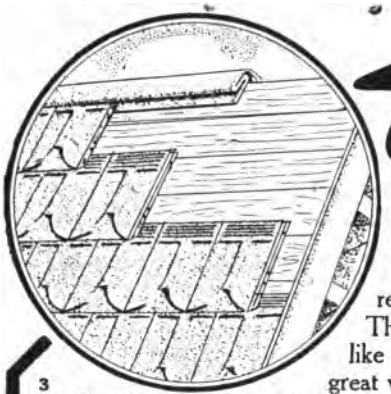
WRITE FOR DETAILS

Chicago Office
933 Monadnock

WILLIAMS, WHITE & CO.
MOLINE, ILL., U. S. A.

Pittsburgh Office
808 House Bldg.

Instead of Wood Shingles or Slate



CORTRIGHT
Metal Shingles

The roofing that lasts as long as the building and never needs repairs.

They won't burn, crack, curl or rot like wood shingles, nor have they the great weight or brittleness of stone slate; besides they are inexpensive and look better than either.

They are used with the greatest success on railroad buildings of all kinds. Before deciding on any roofing for that building you have in mind, get our free book *"Concerning That Roof."* A postcard brings it.

CORTRIGHT METAL ROOFING COMPANY

Philadelphia, Pa. **Chicago, Ill.**

An Industrial Works Convertible Crane Pile Driver

combines the functions, the safety and the labor saving abilities of a locomotive crane and a pile driver. As a pile driver it will drive piles at either side or end of the car. It has a complete battering arrangement. The leader truss is easily removed and regular boom substituted for locomotive crane service.

INDUSTRIAL WORKS, BAY CITY, MICH.

Locomotive and Wrecking Cranes, 5 to 150 tons capacity, Pile Drivers, Transfer Tables Pillar Cranes, Railsaws, Transfer Cranes, Steam Hammers, Grab Buckets

"Chicago Pneumatic" Air Compressor

Gasoline Driven

Is especially adapted for work on Bridges and Buildings where portable outfit is necessary. High Speed—Self Oiling—Self Contained—Direct Connected.

MANUFACTURED BY

CHICAGO PNEUMATIC TOOL CO.

1010 Fisher Bldg. Chicago — **50 Church St.** New York

Branches Everywhere

PROTECTION BRAND

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